The Institute of Physics

BULLETIN

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The Bulletin is published by The Institute of Physics for circulation to its members.

Notices to Members

The Display of the Bulletin in Libraries

The Board has approved a suggestion that copies of the *Bulletin* shall be made available for display in the libraries of universities, recognized technical colleges and grammar schools of which members of the Institute are staff members. Additional copies for this purpose are being sent to honorary representatives in universities and technical colleges. Fellows, Associates and Graduates who are teachers in grammar schools and would like to place a copy of the *Bulletin* in the school library are asked to write to the Deputy Secretary. An additional copy of the *Bulletin* will be sent to them, free of charge, for this purpose. Copies are available only through members.

Payment of Annual Fees

Members who do not pay their fees by banker's order are asked to use the enclosed form and thereby again assist to keep the cost and labour of collecting fees to the minimum. Prompt payment would be appreciated.

The Institute's 1957 Budget

The Board has approved the Institute's Budget for 1957 that has been submitted by the Treasurer on behalf of the Finance and General Purposes Committee. Total income is assumed to be £60,650, which would be about £3,000 more than the likely total for 1956, and some £5,000 above the 1956 budget total. In this income, £37,000 is expected from sales of publications (£33,100 in 1956). A further £8,500 is estimated to be the net revenue from advertisements in the journals, after deduction of agents' commission. The budget figure for members' subscriptions is £14,500.

The total estimated expenditure before allowance for depreciation is £56,700. The production and distribution of publications other than the *Bulletin*, excluding office overheads and Institute staff costs, are expected to cost £20,600 ; salaries, wages, superannuation and National Insurance are estimated at £17,500, of which about half is attributable to the production of publications. The estimated cost of the House, including rent, rates, maintenance and cleaning, is £6,000. The grants to the Institute's Branches and Groups, exclusive of the cost of work appearing on other accounts (House, salaries, printing and stationery) is £2,500.

On the above figures there should be, before allowing for depreciation, etc., a balance of almost £4,000. After charging depreciation at current rates and the payment of the premium on the leasehold redemption policy which will secure £40,000 on the expiry of the lease of the Institute's house, there is a final budget surplus of £1,215.

Graduateship Examination

It was announced in the November *Bulletin* that the 1957 Graduateship Examination would begin on June 10. The date has been changed to June 3.

Oxford Convention

Members are reminded that the third Institute Convention will be held in Oxford from July 10 to July 13, 1957, as was announced in the *Bulletin* in December, 1955. Most of the details of the program are now settled and all members will shortly be receiving programs and forms of application. Accommodation has been booked in colleges. Besides an attractive program of lectures there will be social functions and visits. The lecturers will include Sir Cyril Hinshelwood (*President of The Royal Society*), Sir Maurice Bowra (*Warden of Wadham College, Oxford*), Professor N. F. Mott, Professor A. C. B. Lovell, Dr. A. C. Menzies, Dr. V. E. Cosslett, Mr. Alan Bullock (*Censor, St. Catherine's Society, Oxford*), Dr. J. Topping and Dr. J. Thewlis.

The two previous conventions were very successful and well attended. These were in Buxton in 1949 and Bournemouth in 1953. The principal aim of the Board in arranging this kind of meeting is to provide every opportunity for members in different types of occupation and of all levels of seniority to meet together. It is to be hoped that senior members who are employers will provide their staff, including younger members, with the opportunity of attending. A large proportion of those attending previously have been accompanied by ladies. It is expected that the Convention in Oxford will attract the largest attendance of members and ladies of any Conference that the Institute has ever arranged.

Honorary Representatives

In order to provide a link between the Institute and universities and recognized technical colleges the Board has invited a number of Fellows and Associates to act as its honorary representatives in these institutions. Students and others who wish to have information about membership regulations, examination requirements or Institute publications should inquire of the appropriate representative for relevant forms or published information. The members who have so far accepted the Board's invitation to act as honorary representatives are as follows :—

University of Birmingham	Mr. K. Macfadyen
University of Bristol	Dr. L. C. Jackson
University of Cambridge	Mr. W. Cochran
University of Durham—	
Durham	Professor G. D. Rochester
Newcastle	Dr. N. Thorley
University of Exeter	Dr. K. E. Grew
University of Hull	Professor G. F. J. Garlick
University of Liverpool	Professor J. D. Craggs
University of London :—	
Birkbeck College	Dr. R. Furth
Imperial College of Science and Technology	Dr. R. W. B. Stephens
King's College	Dr. F. C. Champion
Queen Elizabeth College	Miss T. J. Dillon
Queen Mary College	Dr. E. J. Irons
Royal Holloway College	Professor S. Tolansky
University College	Dr. R. E. Gibbs

University of Manchester :—	
Faculty of Technology	Professor H. Lipson
University of Nottingham	Professor L. F. Bates
University of Oxford	Dr. K. A. G. Mendelssohn
University of Reading	Dr. T. B. Rymer
University of Sheffield	Professor W. Sucksmith
University of Southampton	Professor A. M. Taylor
University of Aberdeen	Dr. T. Smith
University of Edinburgh	Mr. R. M. Sillito
University of Glasgow	Dr. G. A. P. Wyllie
University of St. Andrews	Dr. D. Jack
Queen's College, Dundee	Professor G. D. Preston
Queen's University, Belfast	Professor K. G. Emeleus
University College of Wales, Aberystwyth	Mr. I. C. Jones
University College of North Wales, Bangor	Professor E. R. Andrew
University College of South Wales and Monmouthshire, Cardiff	Professor A. J. C. Wilson
University College of Swansea	Mr. L. Wright
University College of North Staffordshire, Keele	Professor F. A. Vick
University College Leicester	Mr. C. A. Haywood
Acton Technical College	Dr. J. Topping
Birmingham College of Technology	Dr. J. H. Davis
Bournemouth College of Technology	Mr. J. B. Hodgson
Bradford Technical College	Dr. D. L. Smare
Brighton Technical College	Dr. N. Pentland
Cardiff College of Technology	Mr. W. S. Vernon
Chatham, Medway College of Technology	Mr. C. H. Smith
Chelmsford, Mid - Essex Technical College	Mr. M. R. Gridley
Croydon Technical College	Mr. H. Falkner
Crumlin, Technical College of Monmouthshire	Dr. T. V. Starkey
Dagenham, South - East Essex Technical College	Mr. H. S. Barlow
Edinburgh, Heriot-Watt College	Professor W. H. J. Childs
Ewell Technical College	Dr. W. Bosley
Glasgow, Royal College of Science and Technology	Professor J. S. Rankin
Huddersfield Technical College	Mr. D. McKerracher
Leeds College of Technology	Mr. J. Holden
Leicester College of Technology	Mr. R. E. Wood
London :—	
Battersea Polytechnic	Dr. H. R. Heath
Borough Polytechnic	Mr. A. J. Collinson
Chelsea Polytechnic	Dr. W. H. George
Northampton Polytechnic	Mr. F. Y. Poynton
Northern Polytechnic	Dr. M. Pillow
Norwood Technical College	Mr. F. J. Crow
The Polytechnic, Regent Street	Dr. J. H. Fewkes
Sir John Cass College	Mr. R. H. Humphry
South-East London Technical College	Mr. R. F. Crocombe
West Ham College of Technology	Dr. A. E. Bate
Woolwich Polytechnic	Dr. D. H. Smith
Loughborough College of Technology	Mr. D. E. Davies
Nottingham Technical College	Dr. A. Middleton
Oxford College of Technology, Art and Commerce	Mr. H. V. Pilling
Paisley Technical College	Mr. W. J. McKechin
Portsmouth College of Technology	Mr. N. J. Dunning
Preston, Harris College of Further Education	Dr. H. Wilkinson
Reading Technical College	Mr. F. Bovey
Rotherham College of Technology	Mr. B. Bradley
Salford, Royal Technical College	Mr. W. G. Darvell
Southend-on-Sea Municipal College	Mr. G. E. Sharp
Sunderland Technical College	Mr. K. E. Pattinson
Swansea Technical College	Mr. W. J. Lewis
Treforest, Glamorgan Technical College	Mr. C. C. Evans
Walthamstow, South-West Essex Technical College	Dr. H. Lowery
Wigan Mining and Technical College -	Mr. C. M. Gateley
Wolverhampton and Staffordshire College of Technology	Mr. E. George

Technical Education: Problems of Quality and Quantity*

By P. F. R. VENABLES, B.Sc., Ph.D., F.R.I.C.

(*Principal, College of Technology, Birmingham*)

THE RELATIONSHIP of quantity and quality is one of the things on which we hear the most unclear thinking—if that is not a contradiction in terms.

I give one illustration in the history of technical education. I think it is fair to say that those who were formerly deprived of opportunity were given chances at the local "tech"; and many a course, particularly a part-time degree course, was established out of that social necessity. As time went on, this position was rectified. The grounds for isolated small groups vanished, particularly with the growth of the scholarship stream in a measure undreamed of before the war. Yet there have been and may still be, for all I know, attempts at keeping very small groups of students isolated from other groups at the same level. This entailed a hidden development of quality because of inadequate quantity. It is a passing condition, in a way, because I think that the White Paper does in some measure rectify that situation.

It is perhaps foolish to touch on a topical and rather contentious point at the outset, but I hope that at least we shall not steer clear of all the contentious issues. I think there is, particularly in a period like that of the White Paper, considerable danger of generally assenting to broad policies which look socially good in themselves without examining in detail the consequences to which they lead and how in fact they are to be implemented.

To do this we need to examine the total problems involved. Secondly, and this is rather more important as I hope to illustrate particularly later, we need to examine the change of pace required in the development which has been going on and how this can be increased to meet the problem which is now set. This change of pace—and that is my third point—is required not merely to make good present deficiencies. It must have a two-fold object—to make good the present deficiencies within the next five years and also during that period to do some positive planning. Otherwise we shall have a permanent and continuing deficiency. The second part is much more difficult to assess than the first one.

Anyone who is planning new building knows that it is very much easier to prove a case in terms of actual "bodies," there and then, and get the allocated space in the expansion or new building, than it is to say that we ought to start this course to meet a need and by this time five years hence we hope to have so many "bodies." We all know the effect of a circuitous argument: "No bodies, no room. Therefore no bodies" which is a defence against expansion in a time of restriction. The Ministry's Circular 242 in effect utilized that to the full.

We have five major aspects to consider: (1) the total and continuing need; (2) the contribution from the schools; (3) the contribution from the technical colleges; (4) the contribution from the universities, and (5) sources of ability. I have not the slightest doubt that many of you would like to talk only about the last point the whole time, but let me say a few words on the total and continuing need.

The Hankey Manpower Committee reports, published by the Ministry of Labour, set out quite conservative estimates of the increased number of technologists, physicists

* A lecture given to the Education Group of the Institute on October 10, 1956.

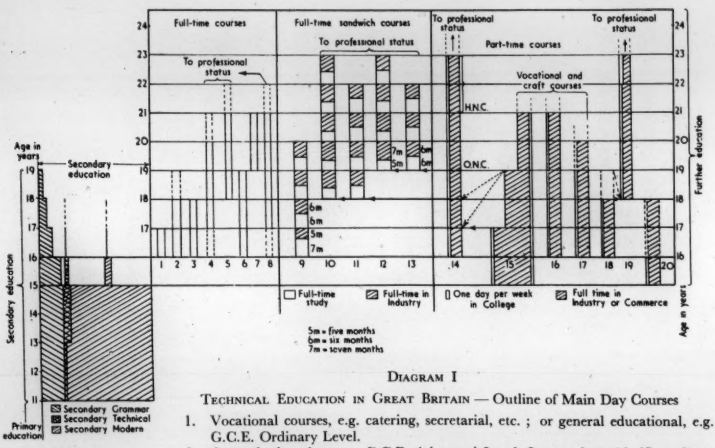

DIAGRAM I

TECHNICAL EDUCATION IN GREAT BRITAIN — Outline of Main Day Courses

1. Vocational courses, e.g. catering, secretarial, etc. ; or general educational, e.g. G.C.E. Ordinary Level.
2. General education, e.g. G.C.E. Advanced Level, 2 years from 16, 17, or later.
3. Vocational courses, 2 years, e.g. hotel catering, secretarial, commercial art ; ordinary diplomas, e.g. building, engineering, textiles.
4. Higher Diploma courses, 3 years, e.g. building, engineering, textiles. Professional courses.
5. University degree course, 3 years, e.g. London University in Engineering, Science, etc. Course for A.R.I.C.
6. Intermediate Examination in Art (Ministry of Education), 3 years.
7. National Diploma in Design (2 years post-Intermediate, or minimum of 4 years of which last two shown).
8. Diploma Course in Architecture for A.R.I.B.A., 5 years.
9-13. Various types of Sandwich courses : 9 recruits at G.C.E. Ordinary Level ; 10, 11 at Second year O.N.C. ; 12, 13 at O.N.C. or Advanced G.C.E.
14. National Certificate Course : 3 years to Ordinary (O.N.C.), then two years to Higher (H.N.C.) ; then 1-3 years for endorsements to exempt from professional examinations.
15. Combined 15-16 years for selection purposes, then to National Certificate or Craft Courses.
16-17. Craft Courses to take City & Guilds examinations, Final at 4 or 5 years, with extra year(s) for Full Technological Certificate.
18. General education G.C.E. Advanced Level, leading to 19, i.e. University final degree course.

and others—conservative seen in retrospect. We can now enjoy the pleasures of hindsight and judge the inadequacy of these reports accordingly. But they judged as best they could according to their lights. If you read the reports of the Central Advisory Council for Scientific Policy, however, you will see that what they say about the estimates falling very far short of what was required has proved to be the case.

I do not propose to go over the question of proving the need. The evidence of this need to fill posts, repeated time and time again for a whole diversity of occupations in the newspaper advertisements, is extraordinarily impressive. You can take many an article such as the authoritative one on the supply of chemical engineers by Sir Harold Hartley in the *Financial Times* recently, or the one on " New Minds for a New World " in the *New Statesman and Nation*, or by Dr. Bronowski on October 7, 1956, in the *Observer*. All this underlines what is everywhere apparent, so I want to turn at once to the contribution from the schools, using the statistics and diagrams provided, to show how many young people are going where.

On the left-hand side of Diagram I you will find a fairly accurately quantitative analysis of secondary education. It shows

TABLE I

ANALYSIS OF AGE GROUPS (15 TO 20 YEARS) IN SCHOOL, COLLEGE, EVENING INSTITUTE AND UNIVERSITY
(England and Wales, 1954/55)

Line		Aged 15	Aged 16	Aged 17	Aged 18/19/20	Line
1	Total Numbers in age group	568,000	573,000	567,000	1,681,000	1
2	Number in *full-time* education :					2
3	School	175,637	92,126	44,895	16,516	3
4	Technical College (Note A)	11,528	10,232	6,507	9,754	4
5	Art College/School	1,404	1,766	1,902	3,542	5
6	University (estimated)	—	—	1,400	42,000	6
7	Training College (estimated)	—	—	—	18,000	7
8	Total in full-time education	188,569	104,124	54,704	89,812	8
9	Percentage of age groups in full-time education	33%	18%	9·8%	5·3%	9
10	Number NOT in full-time education ...	379,431	468,876	513,698	1,591,188	10
11	Number in part-time day release	58,588	81,005	71,658	87,323	11
12	Percentage of age group with day release	9%	14%	12·5%	5%	12
13	Percentage of day release of those NOT in full-time education (Note B)	13·3%	17·2%	14%	5·5%	13
14	Number in Evening classes					14
15	Technical	50,757	87,216	82,468	145,248	15
16	Art	6,417	7,748	7,530	15,412	16
17	Total	57,174	95,064	89,998	160,660	17
18	Total in Evening Classes as percentage of age group	10%	16·5%	16%	10%	18
19	Number in Evening Institutes	107,495	80,442	60,656	74,236	19
20	Percentage of age group attending Evening Institutes	19%	14·5%	11%	4%	20
21	Gross Total of all Evening Classes ...	164,669	175,406	150,654	234,896	21
22	Percentage of age group attending all evening classes	29%	31%	27%	14%	22
23	Total percentage of age group in attendance at all courses (Note C)	71%	63%	49%	24%	23
24	Remaining percentage of age group NOT in attendance (approx.)	29%	37%	52%	76%	24

NOTE A. Figures for National College students (655) not included.

B. The group 18 to 20 is affected by National Service, but many of them likely to be interested in or concerned with day-time courses secure deferment.

C. The percentage is based on the cumulative total, and therefore counts twice those part-time day release students who attend evening classes. Percentages given in line 24 are therefore a conservative estimate.

D. Source : Ministry of Education Report, 1955.

the proportion of children receiving grammar, technical and modern school education. You will notice the diminishing proportion staying at school beyond 15 years of age : the secondary technical school with its entry at 11, but still largely selected at 13, and some going on ; and the great bulk of the secondary modern leaving at 15.

Perhaps you can regard this as a flow sheet, going across to the right-hand side of the page, though this is not quantitative in any sense. It is a diagrammatic representation of the kinds of courses and their duration. These fall into three main groups. The first is full-time courses and these often puzzle the foreigner as to their standard of intake. He is surprised if we say: "Well, if they are not up to the standard, we run a course a year earlier in order to get them up to the standard," and he is apt to be puzzled at our lack of insistence on absolute age entry requirements.

Then there are part-time courses, day courses with industrial experience running parallel through the whole time with college experience. About one-fifth of the space in each case represents college attendance and is unhatched, and the industrial experience is hatched.

After some fifty years' delay, sandwich courses are now beginning to develop. They comprise blocks of full-time study alternating with blocks of full-time industrial experience, and are hatched accordingly in the diagram.

Though this is the general pattern, at the present time there is no clear picture of the way the ability is flowing through all these courses.

It is interesting that there is the greatest diversity of standards in sandwich courses in regard both to entry and transfer points. There are recruits at G.C.E. ordinary level, second year ordinary national certificate, ordinary national certificate and advanced G.C.E.—three years from second year ordinary national certificate, three years from ordinary national certificate, four years in both cases and in some cases even five years. The criteria are not at all clearly established.

Diagram I shows the broad picture but the details are in Table I which is based on an analysis of the official figures. The estimated figures, taken from appropriate sources, are not exact, but their errors do not affect the general conclusions.

Table I shows the percentage of each age group in a particular kind of education. For example, line 9 shows the percentage of age groups in full-time education. At age 15 it is 33 per cent, and this includes, for example, all the people who are continuing at school until the end of the term.

Line 13 concerns the day release group, and at age 15 only 13 per cent of those who are in employment, not in full-time education, are in day release classes. The figure is 17 per cent at 16 ; 14 per cent at 17, and 5 per cent from 18 to 20. As a rough average 14 per cent of people aged 15 to 17 are in day release classes, the county college range, and this after a sevenfold expansion since before the war. To go the whole distance, which I am convinced we shall never do in voluntary terms, we shall need about 20,000 teachers.

All these percentages are summarized in line 23—71 per cent at 15 ; 63 per cent at 16, and 49 per cent at 17—who continue with one form of education or another. These figures actually include those who attend one day plus one evening and so are counted twice, so it is an optimistic figure. Conversely, in line 24, we have a conservative estimate of the number of people who have no contact with education at all. I am stressing this because in my opinion it is the most important place where ability is lost and it is the biggest gap in the educational system.

If you will turn to the small diagram, you will see that this is set out for the previous year. Not all the figures are yet complete for the same year, but there is no significant difference. You will see the falling percentages of those who have contact with the educational system.

Even Diagram II looks far better than the facts warrant because it is really quite fallacious to add a full-time to a part-time to an evening student, as though they

TABLE II

AVERAGE STUDENT HOURS OF ATTENDANCE PER ANNUM
(Technical Institutions only)

Course	Student Hours	No. of Students	Approx. Ratio Student Hrs. p.a.	Approx. Ratio between Courses
(i) Full-time	43,977,816	52,191	842	13
(ii) Part-time Day	60,124,074	370,619	161	3
(iii) Evening	49,016,587	774,301	63	1

were all being educated in equivalent terms, as Table II shows is not so.

Nevertheless the clear part of the diagram represents the proportion of people at the various ages who have no further contact with the educational system.

It is against that background that I want you to look, if you will, at Table II which I was very glad The Institution of Mechanical Engineers got out for me at the time. I am sure it is not true of your professional institution, but I find an astonishing unawareness—I think that is the polite word—on the part of some professional institutions as to where their members came from and what was their educational background.

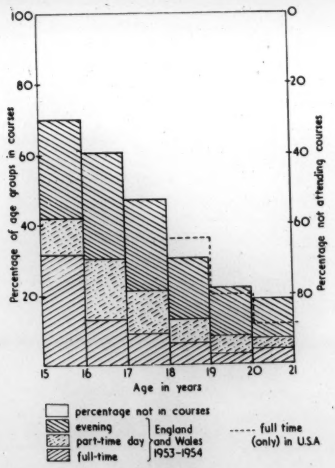

DIAGRAM II

PERCENTAGE OF AGE GROUPS 15-20 YEARS ATTENDING EDUCATIONAL COURSES

Table III gives interesting figures as to the source of people with ordinary and higher national certificates in mechanical engineering : pupils in from the tripartite stream who flowed out, as it were, into the right-hand side of Diagram I and found their way up this route.

There are many implications in this. You can almost use it as a test of a person's background by seeing what questions it raises—a kind of association technique. There are people who will say, " Isn't that interesting ! Clearly if our selection system were better all those who went up the secondary modern route ought to have gone up the grammar route."

Is that true ? Is it demonstrable or are these people the outcome of a mixed bag of social causes. They may have left school early, or simply did not want to stay at school because they were not interested, and then, perhaps, entered a good firm with a sympathetic education officer who looked after them. In addition they went to a college where there was a similar attitude so that eventually they succeeded, though often under difficult conditions.

Again, you may say, for example, that the

TABLE III

ORDINARY AND HIGHER NATIONAL CERTIFICATES IN MECHANICAL ENGINEERING 1952/53

PREVIOUS EDUCATION OF SUCCESSFUL CANDIDATES

	O.N.C.	H.N.C.
Secondary Grammar	47%	45%
Secondary Technical	29%	32%
Secondary Modern	24%	23%
Total Certificates awarded	5,872	2,712
No. of candidates who sat the examination	11,803	4,018

selection system is pure nonsense, but I refuse to be drawn as to whether pupils should come from unilateral, bilateral, trilateral, comprehensive, or incomprehensible schools. But the figures remain and I suggest that there are some awkward questions in them. We ought to ask ourselves whether our system of education is satisfactory. I am not being partisan or anti-grammar-school in this, because plainly these schools make a sizeable contribution to our courses. The *Manchester Guardian* is carrying a very interesting correspondence at the moment on technologists and grammar schools, and on transfer between schools. The grammar school heads in the main assume one and one route only *via* a grammar school and the university, whereas the modern school people are arguing for diversity.

I would venture to suggest that most grammar school heads are unaware of their contribution to the technical colleges, and further that it is rarely acknowledged at the annual school prize-giving.

But this is partly our fault ; and I should like to see the colleges informing the schools of such results, because they cannot all be expected to follow up the cases of their pupils five years later. We could then link up, and help to ensure that the ability is thoroughly looked after and goes up the appropriate route. We may even dispel the general assumption, nonetheless powerful for not being stated, that if a student goes up the full-time route via the grammar school and university and succeeds it is because he went up that route in later life, whereas if he goes via the technical college and succeeds, it is despite the fact he went that way. We ought to have a truly complementary system in this country with university education looking after the truly academic, and the technical colleges looking after those who are more practical-minded, and who thrive on practical industrial experience related to their studies.

Let me come closer to the White Paper, and let us take the first point that is mentioned—the supply of technologists. The White Paper states that we need an increased output from 9,500 to about 15,000 technologists per annum.

The Government puts its money on sandwich courses which are really full-time education for five or six months in a college alternating with similar periods in industry. If we are going to increase the numbers by this amount we shall need 22,000 extra students in sandwich courses. The present figure in all sandwich courses is about 2,000. At the present time there are about 9,000 students on full-time advanced technological courses in the technical institutions out of about 63,000. In five years we must increase that 9,000 to 31,000 altogether.

On the question of technicians and craftsmen the White Paper argues for a doubling of the figure of 355,000 for day release students. Presumably it is to be doubled all along its age range, which includes the 40,000 or so students over 21 years of age paid by employers and still on day release. If we are going to develop at the same rate as during the last six years, fifteen years will be required to double the numbers and the plan says five years. That is over the whole age range, but if we take the restricted county college age range—15 to 17—it will certainly be not less than twelve.

Now let us look at the problem of the supply of teachers. The White Paper stated: " The supply of teachers has recently been growing at the very satisfactory rate of 700 to 800 a year." (Paragraph 102.) To this I would add another fact ; that of the 11,000 teachers in further education only 40 per cent overall are graduates. How many do we need ?

Let us take the advanced sandwich courses and assume a staff ratio of 1 : 10. We need something like 1,500 specialized staff. Then we have to bring the existing courses up to that ratio. A reasonable estimate suggests that we need about 700 more staff for this reason.

At the very minimum, then, not being at all optimistic and taking no account of the proposed new establishment of readerships—which I hope will be mainly research in character—we want something of the order of 2,200 highly specialized and highly

experienced staff for these advanced courses. Everyone would agree that unless we get them in sufficient quantity we can stop talking about quality. You have a very nice example in the teaching profession itself of the acute problem of quality determined by quantity.

In terms of graduate teachers, and not putting it higher than that—e.g. teachers with higher degrees—it means a 50 per cent increase in the graduate establishment within five years. Only recently it was proposed to close down the Bolton training college. The question is, however, whether Bolton, Huddersfield and so on are adequate ; do they attract the kind of people who will largely staff really advanced courses?

The White Paper stresses the part-time day release of staff from industry, but that is not an easy matter. It is highly desirable and I think there will be a move in that direction. But when you consider how many part-time staff are needed even with a simplified timetable it is going to be difficult to secure the requisite numbers. But the problem of sufficient advanced staff for advanced work is really a most acute problem, and I am not talking just administration or figures. It is the critical problem.

When we come to the generality of part-time day courses, what we might call the technicians' and craftsmen's courses, the figure is 355,000, which we can regard as an equivalent load of 90,000 full-time students. This means about 4,500 teachers at a ratio of 1 : 20 or, at a ratio of 1 : 15, some 6,000 teachers will be required in five years' time. No wonder that the Minister has set up a committee.

The total increase is from 11,300 to 19,500 and at a minimum, therefore, we should need a 75 per cent increase in our teaching establishment in five years. This, incidentally, is without any reserve of ex-servicemen coming along and at a time of the most acute competition for ability. I recollect how we in technical education looked on the problem of science teachers in relation to grammar schools and the universities. I suggest that much the same " seed-corn " problem is with us at the present time.

If I may now deal with the supply of building and equipment, everyone knows by now that there are good promises and cash under these heads, £80 million for building and £17 million for equipment. The problem is to turn this into reality.

What is the situation? When a commercial building is going up on a highly expensive site, every day lost is a total loss of income. In education every day lost is only a potential loss of training which no one notices. Yet these two things are inextricably mixed, and somehow we have to develop a conscience on speeding up building to match the problem of development. The most acute problem is to attract students of ability in sufficient numbers to the new colleges, and to match them with the buildings at the proper rate.

On the question of quantity in sufficient quality ; may I hope that one hundred years hence, when people look back on all this building, they will agree that our architects and builders and designers lived up to the challenge of the biggest building programme in educational history in terms of all-round quality of design. We talk a great deal about the quality of our education, and we say a great deal about the influence of extra-curricula activities. The most certain and subtle influence is that of the surroundings, and standards can be raised simply by that alone without saying a word.

Residential facilities are important, but we have to face the fact that these will be very few and far between. They are unlikely to be provided in very many institutions for they are costly. The numbers may grow, but the hope would be for advanced and regional colleges to get all full-time students in college residence for one year some time during a four years' full-time or sandwich course. That would be vastly better than what we have, and one would hope if it were done that it could be done in the first year, so that one could have the students for the most formative period.

May I now turn to the contribution from the universities. Most people are familiar with what is being done there. There is a sizeable expansion at the various universities,

but I want to concentrate on one point. It was stated in Parliament that the universities themselves envisaged an expansion which would mean a rise in student members of 60 per cent in the next five years. This expansion has begun. Imperial College has increased by 60 per cent since its expansion was decided upon. There was a lot of talk about university vacancies and places standing idle in the universities. That is at most a temporary phenomenon. Last year there was an increase, and this year there is a considerable increase in numbers and I think that will vanish as a problem. The number of students taking full-time technology in the universities in 1955 was 7½ per cent up on the previous year, and there is every expectation that that will be maintained this year.

But the interesting point is that when you compare this 60 per cent increase in five years with the expansion of numbers taking G.C.E. advanced level the figures do not indicate anything like the same rate of expansion. Unless a lot of those who previously went in for arts are going to be diverted there will have to be a considerable expansion at school level. The present rate of increase of the G.C.E. A level will have to be increased fourfold in three years' time to take full effect then in order to achieve 60 per cent. Most interesting is the very marked jump in physics over the last two years, and it will be interesting to see whether it is maintained.

I should like to say in the few remaining minutes a word about ability. May I deal quickly with the question of boys and girls. I never did believe that academic ability was a sex-linked characteristic. The apparent differences are a social phenomenon, for example that there should be such figures as the following. In 1955 11,429 boys and 1,642 girls passed G.C.E. Physics A level. The social background to that is partly lack of facilities, partly lack of expectation of employment and partly sheer inertia.

Clearly, if you want this expansion of 60 per cent, you could get it with the girls if you brought them up to the same level. Is that feasible ? Is it possible ? Could it possibly be entertained, and if it could what would it entail ? The figures are very similar all along the line for physics, mathematics and chemistry, and the ratio is nearly seven boys to one girl. What about the missing six ? Do we really consider that they are potentially there and we could get them there in reasonable time ?

Could I just deal with the question of failure to get the ability ? What is, in fact, happening ? Is there any real ability that is not being caught ? The figures from other countries suggest that there might be unless, as modest Britons, we subscribe to the opinion that intelligence is distributed nationally and geographically. They can turn out these considerable numbers in other countries, and I do not care what reservations you make about the standard of output. The figures are not so different as to invalidate the really adverse comparison per million of population, and all the evidence points to ability being available. Recent preliminary researches have shown that there are people with substantial ability, even in the first year national certificate and craft courses, who would merit continued full-time education and sandwich course education thereafter. We simply subject them to all the hazards of part-time education, if we expect them to take their ability to the top level by that route. In this field there is great need for further research. One very interesting possible line of research would be to determine whether there are serious differences in terms of verbal and non-verbal intelligence which can in some general way be linked with promise of a student's success in technical education.

Can we pick out potential students for sandwich courses, of general high intelligence, but with strong ability on other sides preferentially ? This cuts both ways. We get people of high academic ability who should go to universities but there are students there who would do far better in a practical sphere. One of the statements that sticks in my mind is Sir John Wolfenden's alarm—I cannot call it anything else—about " the patient plodders within his institution." Would not many of them have done better

in a far different, more practical, situation ? There is great need for further research to ensure the particular kind of ability takes the most appropriate route.

The general picture is that there is undoubtedly ability of a reasonably good quality available, but that we are really not dealing with it properly in the present situation.

I will finish with a brief comment on the social situation to which I have already referred. Those of us who have been in technical education a long time know full well that after starting with part-time evening courses we persuaded people to support day release. By that means we were enabled to raise standards. We have gone on raising standards, but we have not been able to raise them fast enough nor with sufficient breadth and width. We are faced with the ever-increasing demands of the present development of science and technology, and we really ought now to be saying emphatically that this is not good enough any more. We ought to try to do two things. First we ought to increase the proportion of all young people who go into part-time education anyway. Then we ought to take some of them directly into some system of further education of a full-time character, but with continuing practical experience, as in sandwich courses, and so give them a broader technological education, more firmly based on scientific principles, and not excluding human considerations.

I hope I have said enough to stimulate discussion, if only because I have shown that there are a lot of unsolved problems of quality and quantity in our system of technical education. At the moment, we have about 63,000 full-time students, about 370,000 part-time day students and about 870,000 evening students. I did once hear this diversified system described as " chaos roughly organized." We have got beyond that. Nevertheless, are we quite sure that our direction is right and, in addition to that, in terms of the White Paper, are we sure that our rate of increase and development is going to be adequate for this five-year plan?

Physical Society Meetings

Members of the Institute are invited to attend the following meetings of The Physical Society :—

Jan. 24 — Optical Group

" *Spherical Aberration and the Information Content of Optical Images* "
DR. E. H. LINFOOT and DR. G. BLACK

" *Some Optical Cements : Their Constitutions, Properties and Limitations* "
DR. E. BOVEY

" *Some Properties of Optical Cements* "
DR. R. N. WILSON

At Imperial College, at 2.30 p.m.

Jan. 24 — Acoustics Group

" *The Detection and Measurement of Vibration* "
MR. M. L. PARSEY

At Imperial College at 5.30 p.m.

Vol. 8, January, 1957

The M.K.S. System

or

The Teaching of Elementary Electricity and Magnetism

By Professor H. LIPSON, M.A., D.Sc., F.Inst.P.

(College of Science and Technology, Manchester)

Introduction

During the past session I have been giving the intermediate physics lectures in my department. These lectures are attended by students of almost all the departments of the College, and, although most of them have already taken—and passed—advanced-level G.C.E. physics at school, I try to start from fundamentals and to provide a course which will give a firm basis on which to build in succeeding years. Many of the students will also later receive tuition in electrotechnics and electronics in the Electrical Engineering department, and the Professor of Electrical Engineering suggested that for teaching magnetism and electricity I should use the m.k.s. system, which is used entirely in his department; he thought that the sooner the students were introduced to it, the better.

Reluctantly, I agreed to try the experiment. I say "reluctantly" because nobody would normally change from a system on which he had been brought up to a new system without definite assurance of improvement; and, despite a passionate plea from the Science Masters' Association,(1) I was not convinced that the improvement would be real. Still, I am an experimental physicist, and I thought that the experiment of a new system of teaching might be worth while.

I might be accused of presumption in expounding a subject on which I am not an expert. In defence, I would say that, as a general physicist, I can perhaps see more clearly the impact of the new system on physics teaching as a whole; the electrical or magnetic expert might be too inclined to consider its impact upon his own specialism only.

What is the M.K.S. System?

The new system derives its name from the use of the metre, the kilogram and the second in place of the time-honoured centimetre, gram and second of the c.g.s. system. Here there is some definite improvement; a new unit of force—the newton, 10^5 dynes—appears, but this is the only novelty; the unit of work is the joule, in place of the erg, and the unit of power is the watt, in place of the nameless unit of the c.g.s. system. (But the density of water is 1,000 kg. m^{-3} !)

To adapt the units to electrical requirements, we must introduce at least one of the basic units—the ampere, the volt or the ohm. It is in the manner suggested for introducing these that the first difficulty arises.

Definition of the Ampere

Suppose we start with the ampere. This is usually defined, as all physicists know, in terms of the magnetic effect produced at the centre of curvature of unit arc carrying the current, and leads to an absolute unit which was considered to be too large for practical purposes; it was therefore divided by ten to give the practical unit, the ampere.

The electrical engineer regards the introduction of magnetism as unnecessary; two parallel electric currents attract each other, and we may therefore define the unit of current in terms of this attraction. The following definition of the ampere has therefore been adopted:

The ampere is that current which, flowing in an infinite straight conductor, attracts a current flowing in a similar conductor one metre away with a force of 2×10^{-7} newtons per metre.

This is claimed to be an absolute definition, but it is not so, at least from the physicist's point of view that a unit is that which produces unit effect in unit circumstances.

A SINGLE SYSTEM OF UNITS

By accepting this definition of the ampere, we have eliminated—or, rather, side-stepped—one system of units, the absolute electromagnetic system. The m.k.s. system does more than this ; it also eliminates the electrostatic system of units. This is accomplished quite simply by the adoption of the coulomb—the ampere second—as the unit of charge. What happens then to the law of force between two charges ? An arbitrary constant is introduced, and this is called the permittivity of free space.

Before discussing this concept, however, it is necessary to draw attention to another process, called rationalization.

RATIONALIZATION

Electrical engineers claim that there is an intrusive 4π in many physical equations—for example in the well-known equation

$$B = H + 4\pi I$$

where B = magnetic induction, H = magnetic intensity and I = intensity of magnetization. The 4π that occurs in Maxwell's equations is another example. It is claimed that this 4π occurs because of a misjudgement in the original definitions, as if, according to Heaviside, we had decided to define unit area as the area of a circle of unit radius. We must therefore go back to fundamentals and re-define our basic quantities, or, as the engineers say, *rationalize* them.

This may be done quite simply by modifying Gauss's theorem so that each unit of charge is associated with one line of force instead of the usual 4π lines. Combined with the earlier concept of the permittivity k_0 of free space Coulomb's relationship for the force between two charges of Q_1 and Q_2 coulombs at a distance of r metres apart becomes

$$F = \frac{Q_2 Q_1}{4\pi k_0 r^2}$$

The numerical value of k_0 is found experimentally to be $8{\cdot}84 \times 10^{-12}$.

So far the process seems reasonable, but it fails on the next step, Ampere's law, which becomes

$$dH = \frac{i\, ds \sin\theta}{4\pi r^2}$$

in the usual notation. Note that i is in amperes and s and r are in metres, so that H is not the normal physicist's H. I shall say more of this later ; for the moment we are considering only rationalization. I can see no logical way of introducing the 4π in Ampere's equation, except by analogy with Coulomb's equation. This is unsatisfactory ; the good student will not accept a reason of this sort, and the engineer's justification that it "will help later on" is not an excuse that ought to be used. At least that is how *I* feel ; the advanced students should not have their burdens lightened by increasing the load on the shoulders of the more elementary ones. There is no doubt that the 4π is puzzling.

IS RATIONALIZATION JUSTIFIED ?

Nevertheless, if rationalization introduced overwhelming advantages, there might be something to be said for some elementary discomfort. But I am not convinced. It is said that, with rationalization, π occurs only where it comes in naturally—that is where circular or spherical symmetry is involved. The most important example is the capacity of a parallel-plate condenser, which loses its 4π—very good ! But π is also eliminated from the magnetic field at the centre of a circular coil and from the magnetic field on the axis of a solenoid. One would have thought that π should remain in these formulae.

Anyhow, it is difficult for physicists to work up any indignation about such an old friend as π ; if necessary they use a device such as a special symbol for $h/2\pi$.

And if we can accept that $i^i = e^{-\pi^2}$ we should not be surprised at its appearance anywhere !

THE PHYSICAL PROPERTIES OF FREE SPACE

I have already mentioned the equation

$$dH = \frac{i\,ds\sin\theta}{4\pi r^2}$$

where H is measured in new units, to be discussed later. In order to return to the accepted measurement of magnetic induction, B, we use the equation

$$B = \mu H$$

but give a special value for the permeability of free space,

$\mu_0 = 4\pi \times 10^{-7}$ newton . ampere^{-2}.

We thus have two entirely new concepts—the permeability and the permittivity of free space. These are difficult for physicists to swallow ; no other measurable properties are ascribed to free space. Refractive index is perhaps the nearest parallel, since we may say that this is unity for free space, but refractive index is merely a ratio. In reality, to call these quantities properties of free space is really rather pompous ; they are essentially arbitrary constants which are necessarily introduced in order that when one particular system of units is used, the equations shall give the right answers.

The quantities μ_0 and k_0 are not unrelated ; as advanced students know

$$\mu_0 k_0 = 1/c^2$$

where c is the velocity of light.[1] This equation, however, I consider to be far too subtle for elementary students to appreciate, and I think that it is misleading to recommend, as some books do, that k_0 be presented as having a numerical value of $(1/36\pi) \times 10^{-9}$. Not only is the elementary student perplexed by the sudden confluence of electricity, magnetism and light, but, if he does accept it, he is later deprived of the proper appreciation of one of the grandest conceptions in physics—Maxwell's electromagnetic theory. It creeps in by the back door, as it were, instead of exposing itself dramatically to the students who have properly prepared themselves for its reception !

THE ROLE OF MAGNETISM

Magnetism itself plays only a minor role in the new system ; it is regarded as an odd property that exists in only a few elements. The engineers claim that the proper approach to magnetism should be through its electrical production ; unit magnetic field is that which is produced on the axis of a long solenoid having one ampere-turn per metre. Magnetic induction is that which, when cut by a conductor, produces an e.m.f. in that conductor.

The new unit of magnetic intensity—the ampere-turn per metre—is equal to $4\pi \times 10^{-3}$ oersted. The oersted and the gauss play no part in the new system ; they are relics of a bygone age. Geophysicists and others, please note !

THE ETHICS OF THE SYSTEM

I think that we should also ask whether it is ethical (in an educational sense) to introduce complications in the initial stages of a subject in order to simplify matters later on. Are not the advanced students more capable of adapting themselves to new concepts and able to change more readily from one system to another ? They should be. I have tried to adapt myself to the new system and to rid my mind of any preconceptions introduced by my own training, but I do not regard the new system as logical. Too often one has to say that " this will be explained later." The basic definition—that of the ampere—falls into this category ; the force cannot be " explained " until magnetism has been dealt with. If someone could produce a field theory in which the force between two currents could be accepted as basic, in the sense that the force between two charges or two magnetic poles is accepted as basic at present, there would be a possibility of rationalizing (dare I use the word ?) the new teaching. But two similar currents attract, and so such a field theory would be quite dissimilar from any we know. Will any of my readers accept the challenge ? Or has the theory already been produced ?

COMPROMISES

I realize that I may be accused of giving a biased view of the new system. It is always difficult to refute such a charge, and I can only plead that at least I have not been so

biased that I have refused to use it. I am quite prepared to accept the electrical engineer's view that the m.k.s. system is good because it simplifies the solution of practical problems. But that is a technologist's criterion, not a physicist's. The physicist, certainly at an elementary level, is more concerned with understanding general principles, and the m.k.s. system does not appear well suited to this.

I think that a compromise, which I myself propose to use, is possible. I shall revert to the c.g.s. system with its (I admit) confusing three systems of units, but shall try to show, wherever possible, how practical results can be derived by the introduction of the arbitrary constants, μ_0 and k_0; these shall however be anonymous. Permeability and permittivity I shall retain with the physicist's convention that they are numerically equal to unity for free space. Some points, particularly the relationship between magnetic intensity and magnetic induction, emerge more clearly on the new system, and these, wherever possible, I shall incorporate. For example, the equation

$$B = H + 4\pi I$$

shall become

$$B = \mu_0 H + 4\pi I$$

To the electrical engineer's claim that it is best for the student to be introduced initially to the system he will have to use later, I would say that I do not agree. The introduction of new concepts may need methods different from those used for their practical utilization.

I have just been reading a most fascinating book on Faraday.(2) It seems to me that a student brought up on the m.k.s. system would hardly understand Faraday's approach at all, with its emphasis on magnetic poles. I agree that teaching must move with the times; but dare we cut ourselves off from our roots?

APOLOGIA

It is certain that increasing pressure will be brought to bear on physics departments to use the new system. It may be right that they should use it and that the objections I have raised are trivial compared with its advantages. It is possible (or more likely probable) that I have misjudged certain of its qualities, and, if so, I should welcome the necessary correction. But I think that all physics departments should be aware of both sides of the question before they consider giving up a system which has served them well for so long.

REFERENCES

1. *The Teaching of Electricity.* London: Murray.
2. *Faraday's Discovery of Electromagnetic Induction.* Martin. London: Edward Arnold.

Forthcoming Institute Meetings

Jan. 18 Scottish Branch
In the Regional Physics Department, 9-13 West Graham Street, Glasgow, 7.15 p.m.
"*New Photographic Materials and Processes*"
MR. A. HORDER
(Ilford Ltd.)

Jan. 18 Non-Destructive Testing Group — At the Institute's House, 6.30 p.m.
"*Radiological Protection — the Present View*"
MR. E. E. SMITH, A.Inst.P.
(Radiological Protection Service)

Jan. 19 Liverpool and North Wales Branch — At The University of Liverpool

One Day Meeting on

" *The Shortage of Physicists* "

Jan. 21 Scottish Branch

In the Natural Philosophy Department, The University of Edinburgh, 7.15 p.m.

" *The Physiological Effects of High Speed Flying* "

GROUP CAPTAIN W. K. STEWART, C.B.E., A.F.C.

(Royal Air Force Institute of Aviation Medicine)

Jan. 22 Scottish Branch

In the Natural Philosophy Department, The University of Glasgow, 7.15 p.m.

" *The Physiological Effects of High Speed Flying* "

GROUP CAPTAIN W. K. STEWART, C.B.E., A.F.C.

(Royal Air Force Institute of Aviation Medicine)

Jan. 23 Midland Branch — At the Birmingham Exchange and Engineering Centre, 7 p.m.

" *The Physics of Weather Forecasting* "

MR. J. S. SAWYER

(Meteorological Office, Air Ministry)

Jan. 23 Education Group — At the Institute's House, 6 p.m.

" *The Origin of Modern Physics* "

PROFESSOR H. DINGLE

Tea will be served at 5.30 p.m.

Jan. 25 North Eastern Branch — At King's College, Newcastle, 6.15 p.m.

" *The Effects of Irradiation on the Physical Properties of Solids* "

DR. M. J. MAKIN

(Atomic Energy Research Establishment, Harwell)

Jan. 25 Scottish Branch

In the Regional Physics Department, 9-13 West Graham Street, Glasgow, 7.15 p.m.

" *Transistors and their Applications* "

MR. K. W. CATTERMOLE

(Standard Telecommunication Laboratories Ltd., Enfield)

Feb. 1 Scottish Branch

In the Regional Physics Department, 9-13 West Graham Street, Glasgow, 7.15 p.m.

" *Some New Magnetic and Electrical Ceramics* "

MR. G. CAMPBELL

(The Plessey Co., Towcester)

Feb. 6 Education Group — At the Institute's House, 6 p.m.

" *Technological Education in Russia* "

MR. P. E. SLEIGHT
(Brighton Technical College)

Tea will be served at 5.30 p.m.

Feb. 8 Liverpool and North Wales Branch

In the Department of Electrical Engineering, University of Liverpool, 7 p.m.

" *Applications of Physical Methods to Industrial Chemical Research* "

MR. R. J. TAYLOR, F.Inst.P.
(Unilever Ltd.)

Tea will be served at 6.30 p.m.

Feb. 8 Manchester and District Branch

In the Bragg Building, University of Manchester, 6.30 p.m.

Branch Annual General Meeting
followed by
" *Exploration of the Upper Atmosphere using Rocket Vehicles* "

PROFESSOR H. S. W. MASSEY, F.R.S.
(University College, London)

Feb. 8 South Wales Branch — At University College, Cardiff, 5.15 p.m.

" *A Physical Basis of Colour Photography* "

DR. R. W. G. HUNT
(Kodak Ltd.)

Feb. 12 Midland Branch — At the Birmingham Exchange and Engineering Centre, 7 p.m.

" *The Theory of Practical Joking and its relation to Physics* "

PROFESSOR R. V. JONES, F.Inst.P.
(University of Aberdeen)

Feb. 12 Scottish Branch

In the Natural Philosophy Department, The University of Glasgow, 7.15 p.m.

" *Cosmic Rays* "

DR. T. E. CRANSHAW
(Atomic Energy Research Establishment, Harwell)

Feb. 13 Yorkshire Branch — At The University of Leeds, 7.30 p.m.

" *The International Geophysical Year : the Premature Cosmic Ray Increase of February 23, 1956* "

PROFESSOR J. G. WILSON, F.Inst.P.
(University of Leeds)

Feb. 14 North Eastern Branch — At Sunderland Technical College, 6 p.m.

" *Non-destructive testing* "

DR. E. G. STANFORD, A.Inst.P.
(Aluminium Laboratories Ltd.)

Tea will be served at 5.30 p.m.

Vol. 8, January, 1957

Salary Survey—1956

REPORT ON A SURVEY OF SALARIES AND EMOLUMENTS PAID TO FELLOWS, ASSOCIATES AND GRADUATES OF THE INSTITUTE OF PHYSICS OCTOBER, 1956

(This report is not to be reproduced in whole or in part without the written permission of The Institute of Physics)

THE DATA given in this report are derived from the fourth emolument inquiry made by The Institute of Physics, the earlier ones being in 1948, 1951 and 1953. The present data are the annual rates of salary and other emoluments—the nature of emoluments included being referred to later —received by Fellows, Associates and Graduates of the Institute in Great Britain at October 1, 1956.

The salary reports published by the Institute are not intended to be simple guides to salaries appropriate to graduates in physics. No such guide is, in fact, possible and the data here given should not be so interpreted. They are a factual record of the emoluments received by some three-quarters of those members of the Institute of whom inquiry was made.

There are significantly large differences between the average levels of emolument of the three grades although, of course, the variation within grades is such that there are some individual overlappings. For example, some Associates in senior positions, men who would probably be eligible for transfer to Fellowship if they applied, have incomes similar to the average level for Fellows ; nevertheless, the differences between grades are clearly significant and it is therefore important that the results should be interpreted in the light of the Institute's requirements for membership of the various grades. Graduateship is open to holders of approved qualifications in physics who are, at the time of their application, engaged in work that is considered to be appropriate to a professional physicist. The standard of academic knowledge demanded is an approved degree or an examination qualification deemed by the Institute to be equivalent to an honours or special degree in physics. The minimum age for this grade is 21 years. For Associateship and Fellowship the minimum academic requirement is the same as for Graduateship ; in addition, periods of approved professional experience in physics are required. For Associateship, for which the minimum age is 25 years, the minimum periods of experience are three or five years according to the class of degree held. For Fellowship, minimum age 30 years, a very high standard of scientific attainment or responsibility is demanded and the minimum period of experience is seven years for original research or ten for those applying on the basis of other responsible work in physics. For both the grades of Fellow and Associate (the two corporate grades of membership), experience is very carefully investigated and real evidence of originality and initiative is required, especially for Fellowship. For most physicists the Graduate grade is the normal avenue to Associateship and most Graduates would expect to transfer to Associateship after a few years' experience. However, there will be a substantial minority who are not engaged in work that offers the opportunity of displaying the qualities required for Associateship or whose abilities do not permit them to comply with the regulations for transfer, and it is therefore to be expected that the grade of Graduate will continue to include some older physicists of less ability than those in the Associate grade ; it is also to be expected that this would be reflected in the respective salaries. Similarly,

there are many Associates who will not be able to meet the requirements for transfer to Fellowship.

DATA RECEIVED

Inquiry cards were sent to all Fellows, Associates and Graduates living in Great Britain. The response has been about the same as in 1953 and better than in the two earlier surveys. The details are given in Table 1.

Table 1. *Cards sent and returned*

Grades	*Cards sent*	*Returned*	*Percentage*
Fellow	803	538	(67%)
Associate ...	1,734	1,326	(76%)
Graduate	921	675	(73%)
	3,458	2,539	(73%)

CLASSIFICATION

The classification of different occupations was somewhat different from that adopted in the earlier surveys. Members were asked to indicate their occupational category according to the reference letters listed in Table 2.

Table 2. *Occupational Categories*

Reference letter	
	Employee in or under—
A	Industry (not nationalized)—including an executive director
	Nationalized Industry :—
B	Transport (including Railways)
C	Coal
D	Gas
E	Electricity
F	U.K. Atomic Energy Authority
G	Scientific Civil Service
H	Other branch of central Government service
J	Local Authority (not a teacher : cf. P, Q) or Public Utility undertaking (not nationalized)
K	Hospital (except posts more appropriately included in N)
L	Research Association
N	University or university college (including medical school). Not research student—see T.
P	Technical College—including a Principal
Q	School—including a Headmaster or Headmistress
R	Other field of employment
S	Employer or Self-Employed
	Other Category—
T	Student dependent on Research or Maintenance Grant
U	On National Service
V	Retired and not fully re-employed (If fully re-employed, use the appropriate category above)
W	Unemployed, if under the retiring age for the last employment

This classification was arrived at in agreement with the officers of The Royal Institute of Chemistry in order that some comparison of the results of inquiries conducted by the two Institutes should be possible. The report of a recent survey carried out by The Royal Institute of Chemistry has been published in the *Journal* of that Institute (Volume 80, September, 1956, page 518).

The returns from members are shown in Table 3, classified by age, grade and occupation. It will be noticed that women members are shown separately. Throughout this report, unless it is stated otherwise, all salaries and numbers refer to *males* only. A few cards were excluded from the analysis because of ambiguity but some for which the occupational category was ambiguous have been included under "other scientific posts." Among cards excluded are those from regular members of the armed forces and from employees of overseas firms or governments.

EMOLUMENTS INCLUDED

Salaried employees were asked to give details of gross salary, including additional remuneration such as bonuses, shares in profits and allowances other than for expenses, but not including any contributions made by an employer under a superannuation scheme. They were asked to give separately any other remuneration that they derived from professional work and that was consistent with, although not part of, the salaried employment. The kind of work envisaged was external examining or consultative work undertaken by university teachers. For the purpose of this report the same procedure has been adopted as in earlier reports ; the only additional remuneration that has, in fact, been included in the analysis is that for teachers in universities and technical colleges and, where the additional remuneration is

substantial—from book royalties, etc.—for a few school teachers. The additional earnings of all other salaried members have been disregarded. Very few industrial and other employees have such earnings and those are usually very small. Additional emoluments of this kind, however, are a recognized part of the financial opportunities of university service and a high proportion of senior university physicists have additional earnings of a few hundred pounds a year ; in a few cases the earnings are, in fact, greater than the university salaries of the members concerned. It should perhaps be pointed out that this is one of the respects in which the analysis in this report is not strictly comparable with that of The Royal Institute of Chemistry. In that Institute it has been the practice in the past, as in their latest inquiry, not to separate salary and other emoluments so that the total earnings of all members are included. It has been thought better, however, to follow here the practice that The Institute of Physics has previously adopted. For all members other than the more senior ones in university posts, a small number of those in technical college posts and some half-dozen schoolmasters, the emoluments referred to here are unambiguously the salaries paid by employers.

Members who are not in salaried employment were asked to give their total annual earnings in the fiscal year ending April 5, 1956, subject to any adjustments for known changes that have since become effective. As will be seen from Table 3, the number of such members is trivially small.

BASIS OF PRESENTATION

Earlier Institute of Physics surveys have given information on the variation with age of mean salaries of Associates and Graduates. They have also given some indication of the variation of salaries within these grades. As the variation is considerable for older men, there are objections to the use of the mean as a reliable statistic. It has therefore been decided to use the median salary throughout instead of the mean. It has been the aim of earlier reports to present a reliable broad picture of salaries within the profession

Table 3. *Classification of returns by ages and occupations*

Occupational group /Grade	*Age group*	*Under 31*			*31–40*			*41–50*			*51–60*			*61 and over*			*All ages*			*Women*	
		F	*A*	*G*	*F*	*A*	*G*	*F*	*A*	*G*	*F*	*A*	*G*	*F*	*A*	*G*	*F*	*A*	*G*	*T*	*All grades*	*Total*
A—Industry		—	159	284	36	249	58	66	67	1	36	13	—	13	2	—	15	151	490	343	984	15	997
B, C, D, E—Nationalized Industry		—	9	11	3	10	2	6	8	—	—	—	—	—	—	—	—	27	13	54	94	52	52
F—U.K. Atomic Energy Authority		—	11	20	3	40	2	4	12	—	1	2	—	—	—	—	—	16	83	42	141	2	143
G—Scientific Civil Service		—	27	57	9	92	15	4	12	—	2	4	—	—	—	—	4	61	157	49	267	4	271
H - J—Other Government and local government service		—	26	31	9	96	17	29	31	—	19	23	—	4	—	—	4	61	157	49	267	4	271
K—Hospital		—	4	9	—	17	4	21	9	11	7	3	—	1	—	—	1	17	35	8	60	1	61
L—Research Association		1	11	21	8	30	—	23	4	—	5	—	—	—	—	—	—	18	35	9	62	5	67
N—University		—	38	32	31	98	6	23	7	—	12	—	—	—	—	—	—	45	57	22	124	8	132
P—Technical College		—	18	14	2	55	2	49	15	—	2	—	—	—	—	—	—	115	134	16	285	2	287
Q—School		—	12	12	3	55	9	16	40	2	15	2	—	1	—	—	1	85	138	10	233	5	238
R—Other posts		—	2	21	1	20	9	3	37	2	19	2	—	2	—	—	2	10	88	32	130	5	135
		—	9	30	1	26	1	3	2	—	1	4	—	—	—	—	—	7	23	9	39	3	42
Total		3	319	447	110	656	113	216	236	6	124	60	—	30	6	—	36	483	1277	566	2326	48	2374
Self-employed	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	7	2	14		
Retired	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	37	6	1	44		
Women professionally employed	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	27	21	20	68		
Research grants	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	—	—	3	73		
National service	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	—	—	3	15	18	
Unemployed	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	—	1	2	1	18	
Excluded for various reasons, including ambiguity		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11	7	—	18		
Total cards returned		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	538	1326	675	2539		

rather than to publish a great deal of numerical data which, with the comparatively small number of physicists, might be much less informative. The same principle is followed here.

VARIATION OF EMOLUMENTS WITH AGE

Figure 1 shows smooth curves of the median salaries of the members of the three grades, of all occupations. For purposes of comparison, the curves showing the mean salaries of Associates and Graduates in industry in 1953 are also given. These industrial salaries were in 1953 significantly higher than the rates paid in other occupations. It will be seen that the level of emoluments is now considerably higher than in 1953. The median salary of all younger men

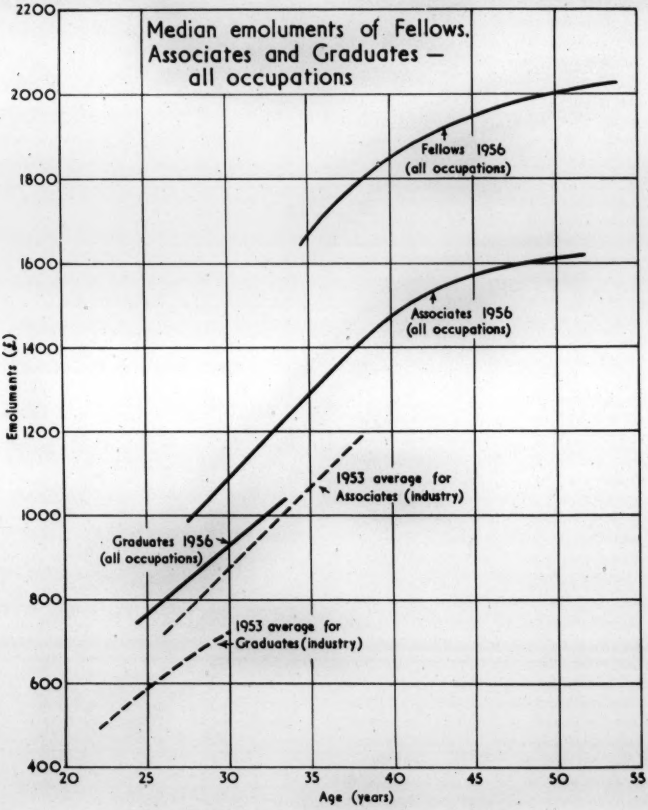

FIG. 1.—MEDIAN EMOLUMENTS FOR THREE GRADES SEPARATELY

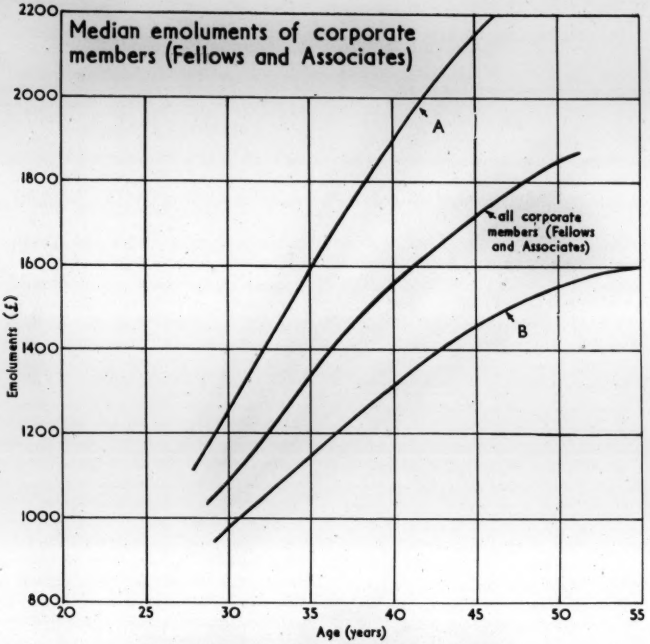

FIG. 2.—MEDIAN EMOLUMENTS OF ALL CORPORATE MEMBERS
About 50-60% of returns lie within the curves A and B

(those in the Graduate grade) are some £200 a year higher than the rates paid in 1953 to the highest occupational group, an increase of 25–30%. For Associates the increase generally has been of a similar order.

Figure 2 shows the median salary of all corporate members (all Fellows and Associates) for all occupational groups and also shows the curves between which about 50–60% of the returns lie. This diagram is roughly comparable with the diagram given in the report of The Royal Institute of Chemistry.

VARIATION WITHIN GRADES

(*a*) Fellows

The increase in the level of emoluments has been general and has not been confined to the younger man. Emoluments of Fellows appear to have increased in general by about the same proportion as have those of young graduates. Table 4 shows the distribution of incomes of Fellows according to occupation. It may be compared with Table 3 of the 1953 report and for purposes of comparison the percentage of Fellows in each salary class in 1953 is given here.

Taking first the Fellows under 41 years of age, it will be seen that the proportion earning £1,500 and upwards has increased from 34% to 66% and those earning upwards of £2,000 p.a. are now 35% as against 13% in 1953. For the larger number of Fellows over 41 years of age, the proportion earning £1,500 and over has increased from 62% to

Table 4. *Emoluments of Fellows*

Occupational Group	*Age Under 41*							*Age Over 41*						
	Under £1,000	£1,000 £1,499	£1,500 £1,999	£2,000 £2,499	£2,500 £2,999	£3,000 £3,999	Total under 41 years	Under £1,000	£1,000 £1,499	£1,500 £1,999	£2,000 £2,499	£2,500 £2,999	£3,000 £3,999	£4,000 and over	Total over 41 years
A—Industry	—	7	13	10	3	3	36	—	11	30	28	15	17	14	115
G—Sci. Civil Service	—	2	1	6	—	—	9	—	3	26	17	5	1	—	52
L—Research Assn.	—	4	3	2	—	—	9	1	6	11	12	2	3	1	36
N—University	—	15	8	5	2	2	32	—	12	26	21	13	10	1	83
P—Tech. Colleges	—	1	2	—	—	—	3	—	2	23	4	1	—	—	30
All other	—	9	8	4	1	2	24	2	6	22	16	6	1	1	54
Total	—	38	35	27	6	7	113	3	40	138	98	42	32	17	370
Per cent in each salary Class ...	—	34	31	24	5	6		1	11	37	26	11	9	5	
1953 per cent in salary Class ...	8	58	21	10	3			3	35	34	17	6	4		

88% and of those earning £2,000 and over has increased from 27% to 52%. The median salary of Fellows of all ages and occupations, which was £1,400 in 1951 and £1,550 in 1953, is now approximately £1,950.

Of the seventeen returns showing salaries of £4,000 and upwards, ten were of sums over £5,000.

(*b*) Associates

The general picture of the relative emoluments of different occupational groups is broadly similar to that of earlier surveys. The salaries paid in industry to younger Associates are slightly above the general average but the most significant variation from the curve shown in Figure 1 is that Associates in industry over the age of 40 have median salaries which become progressively higher than the general average, being, at the age 45, about £150 higher. In the three previous surveys Associates in the Scientific Civil Service have had mean salaries about £50 annually below those paid in industry but it now appears that there is no significant difference, at least for men below the age of about 40, between the salaries paid by the Government and by industry. Below that age the curves of median salaries of Associates in these two groups would be barely distinguishable. Of the occupational groups considered in previous surveys it would seem that those in Government service have had a somewhat greater proportionate increase than any other. The median salaries of Associates in university posts (nearly all under 40 years of age) are fairly close to the curve for all Associates, except for the youngest men in the group ; these latter are rather below the average. The relative attractiveness of technical college teaching for the young man is again demonstrated, the median salary for men under about 35 being about £50 higher than the general average, but, as before, the older Associates in technical colleges have salaries below the average. The median for the older man is about £1,450. The median of the maximum salaries of the Associates who are schoolmasters is approximately £1,400. The median for the younger schoolmaster is about the general average. For teachers in technical colleges and schools the spread of salaries is less than for other groups.

Although the numbers involved are comparatively small, the returns suggest that Associates employed by the United Kingdom Atomic Energy Authority have salaries which are significantly above the general average.

Of Associates in all occupations, 81 returned salaries of £2,000 and over, 27 of these being from men under the age of 41. Of these 81 returns, five were of salaries of £4,000 and upwards, four of these five being from men in industry.

(*c*) Graduates

The number of Graduates in any one occupational group other than industry is hardly sufficient to justify further comment.

WOMEN

The number of women professionally engaged is small. It is not possible to comment upon their salaries in detail ; the general level is below that of men, especially in the higher age groups.

The data have been analysed and the report written by Mr. N. Clarke (*Deputy Secretary*); the publication of the report has been authorized by the Board.

Reviews of Books

ELEMENTARY NUCLEAR THEORY

By H. A. Bethe and P. Morrison

London : Chapman & Hall Ltd. Pp. 279. Price 50s. Second Edition.

In the preface to the first edition of this book Professor Bethe began : " This book is not meant to be a text-book of the theory of atomic nuclei. It is merely a selection of certain topics in the theory, and even these topics are treated in only an elementary way." Now provided the prospective purchaser or reader knows what is meant by elementary, this is a perfectly satisfactory description of the second edition too. But there is as much scope for confusion in the use of adjectives such as advanced or elementary in book titles as there used to be (and perhaps still is) in the nomenclature of electromagnetic radiations, and if authors wish to use these terms it would be useful if they would provide, in a sub-title or introduction, some indication of what they understand them to mean. A mathematical physicist specializing in nuclear physics will certainly find the treatment in this book elementary, but a third-year undergraduate will find it elementary only in a mathematical sense. Even to read it intelligently, without necessarily becoming familiar with its contents, demands a fairly advanced knowledge of modern physics and, in particular, of the nature of the theoretical methods of atomic physics.

But this should not be taken as adverse criticism for, of its kind, this is an excellent book. Its main theme is the problem of nuclear forces, treated entirely empirically but in a way that brings out clearly the nature of the experimental evidence and the methods of approach to the problem. There is also an account of the theory of beta-disintegration, but alpha radioactivity and the fission process are specifically omitted. This second edition has been revised to include the results of recent high energy experiments, and also devotes more space to the structure and reactions of heavier nuclei and to meson field theory.

This book can be recommended to the reader who wants an authoritative account of these aspects of nuclear theory, and who is prepared to make a thorough study of them.

A. E. DE BARR.

AN INTRODUCTION TO CYBERNETICS

By W. Ross Ashby

London : Chapman and Hall Ltd. Pp. 294. Price 36s.

One of the developers of Cybernetics, Wiener, defined it as " the science of control and communication in the animal and the machine "—which roughly amounts to defining it as the art of steersmanship. After reading the book the reviewer is inclined to amplify this by the analogy that Cybernetics is to Planning as Thermodynamics is to Chemistry.

Before saying more about the book as a textbook I would say that it is an exciting book to read ; the author brings quantitative and logical ways of thinking into every possible field with a clarity which is refreshing. Furthermore, the problems set as Exercises used to illustrate the text are so attractively selected that one can hardly read the book without stopping to work them out. This is a great virtue in a textbook with a modest title.

Part one of the book deals with Mechanisms, and refines the definition of a machine, then extends it to include the black box—the system with uniform but not initially predictable relationships between its input and output states. Part two deals with Variety, as defined in communications theory ; and after reading this no one should again heedlessly exclaim " What I need is a bit of variety " since the claim is absurdly modest. This part of the book brings into relationship the ideas of entropy and of noise, and its quantitative estimation.

The author uses mathematics discreetly: we are asked to form matrices of probabilities, but never called upon to use the differential calculus.

In the third part regulatory and control mechanisms are defined ; and the difficult synthesis between mathematics and biology is gradually developed. The relationship between the regulatory system, as defined in this book, and the theory of genes is explained. The implication that genetics is the mechanism of a regulatory system will be a novel idea to many readers, and although this is referred to more than once it is not fully worked out here. The final chapters deal with questions which hardly come within the scope of an introduction, but are worth including to indicate the probable directions of growth of the subject of cybernetics ; they outline the theory of regulatory mechanisms as applicable to very large systems, and proceed to the question of amplification ; the measurement of amplification, and finally the possibility of amplifying intelligence.

The book can be recommended not only to students of planning, physics, biology and mathematics but also to people who like solving puzzles. The author delights to refute people who still hold to the old distinction between precise sciences and merely descriptive branches of natural history, by bringing logical and quantitative ways of thought to every kind of science.

E. VAN SOMEREN.

INTRODUCTORY COURSE IN COLLEGE PHYSICS

By N. H. Black and E. P. Little

London : The Macmillan Co. Pp. 786. Price 47s. Fourth Edition.

This is the fourth edition of a well-known work on General Physics of college standard in America or Sixth Form standard in Britain. The general lay-out of the book is unchanged, the arrangement being Mechanics and Properties of Matter, Heat, Magnetism and Electricity, Sound and Light ; and the authors' claim " to present the classical topics of physics in an understandable and accurate form " is well substantiated.

When compared with previous editions it is obvious that a very full revision of the text has been made to bring it into line with modern developments and it is unusual to find in a book of this standard solid state theory, crystal diode, transistor, nuclear physics and transuranium elements in a form which the " A " level candidate would find useful as an introduction to more detailed reading.

The text, as is common to most American books of this standard, is descriptive, with the minimum mathematical treatment, and profusely illustrated with line, half-tone and colour plates. It is difficult to describe its standard to a British reader as it does not fit into our system of teaching but it would be very suitable as a general reader in a First Year Sixth Form Course, particularly for candidates later specializing in Biology and Medicine. A summary and the usual questions and problems are put at the end of each chapter, these demanding considerable care and thought for a good answer. Many of these problems will require additional reading and will furnish a stimulus to students with inquring minds. In the Appendix a useful bibliography is included and the majority of the books in it are easily obtainable in this country.

The book is beautifully produced and very well bound. It can be thoroughly recommended for inclusion in a school library.

W. B. CHIVERS.

TRANSISTORS IN RADIO AND TELEVISION

By M. S. Kiver

London : McGraw Hill Book Co. Ltd. Pp. 324 + vii. Price 37s. 6d.

This book essentially deals with the applications of transistors to radio apparatus. The author suggests, in his preface, that the book can be used in a variety of teaching institutions and for " home study." It is clearly a book for electronics technicians with suitable qualifications and for engineering graduates whose interests lie in the applied

fields. Consequently it would, perhaps, not have a very wide appeal to physics under-graduates, although those who have a special interest in electronics might derive benefit from it. In some university engineering departments in Britain it might, and probably will be, of more interest, since it includes sections on the qualitative theory of transistors and their development and gives many applications to circuit problems

It is notoriously difficult to explain the theoretical background of semi-conductors from first principles and to a satisfactory degree to electronic engineering undergraduates and it is indeed doubtful whether the kind of explanation given in the present book, and many other books, is of much value, although this is certainly a matter of opinion.

The present work includes chapters on modern electron theory (very qualitative), point contact and junction transistors, transistor amplifiers, transistor oscillograms and transistors in radio and television receivers. There is also an interesting chapter on experiments with transistors and many of these would be of great value in the earlier undergraduate years. Some 13 experiments are given in fair detail, and including even lists of component values, etc.

The technical production of the book and, in particular, the diagrams (of circuits and transistor characteristics, etc.) are excellent.

J. D. Craggs.

EXPERIMENTAL PHYSICS

By C. B. Daish and D. H. Fender

London : The English Universities Press Ltd. Pp. 338. Price 18s.

The feature which makes this book of great value to a student is the treatment which it gives to the estimation of errors. There is an excellent chapter at the end of the book in which errors are analysed in a way readily understandable by the student, who is encouraged to estimate his errors right from the beginning of the course.

On the jacket, the book is described as a " complete course in Practical Physics for the student working for the General Certificate of Education at Advanced Level, and progressing to Scholarship work," and is one of the series on Physics and Mathematics written by a team of experienced teachers from the Royal Military College of Science.

At the beginning of each section, the relevant theory has been " sketched in." Provided that the student has already studied the theory, this would seem to be unnecessary. Its omission would have reduced the size (and probably the cost) of the book, or made possible a better lay-out for the descriptions of experiments, which are rather crowded : the good psychological effect of one experiment, one page, is lost.

There is a very helpful chapter on the use of graphs and the book contains many useful practical hints such as methods of drawing tangents and the use of a " distance piece " in optical bench experiments. In a chapter full of excellent advice on " How to carry out an experiment and write it up," there seems to be no justification for the statement that arithmetical working need not be shown. Also the printing of specimen results in a good proportion of the experiments robs the experimenter of some of the sense of adventure.

This book is to be recommended, particularly for the more able student.

Kathleen E. Parks.

MODERN PHYSICS : A TEXTBOOK FOR ENGINEERS

By R. L. Sproule

London : Chapman and Hall Ltd. ; New York : J. Wiley and Sons Inc., 1956. Pp. xii + 491. Price 62s.

The last two decades have witnessed, to an unprecedented extent, the application of the concepts and techniques of modern physics to large-scale engineering projects and to methods of measurement and control of importance in engineering. Consequently, a sound general knowledge of modern physics is essential to every engineer nowadays.

This book is an excellent presentation of modern physics, covering the wide fields of atomic, nuclear and solid state physics,

suitable for the engineering undergraduate who has a basic knowledge of classical mechanics, electricity and magnetism.

The first chapters describe the elementary particles, assemblages of particles, mean free path and atomic sizes, and the Rutherford model of the atom. Then there is a good chapter showing the need for a quantum theory (photoelectric effect, line spectra, etc.) and a discussion of the indeterminacy principle. Wave mechanics is then presented, starting with Schrödinger's equation, which is applied first to simple square well potentials to indicate how such effects as discrete energy levels and barrier penetration arise. Wave mechanics is used throughout the remainder of the book which comprises the properties of atoms, molecules, crystals, conductors, non-conductors and semi-conductors. There is a final chapter giving the essentials of nuclear physics and radioactivity.

The author rightly contends that no serious engineer should, or need, avoid wave mechanics, and he certainly succeeds in giving its essential features, and physical interpretation, with undue mathematical difficulty.

The engineering applications of physical results are emphasized throughout. For example, the section on elementary particles leads to a description of the main types of particle accelerator ; nuclear binding energies lead to mass spectrometers and the principles of focusing used ; semi-conductors lead to transistors ; the section on fission leads to a description of three typical nuclear reactors.

The book can be recommended also to the physics undergraduate as an introduction to modern physics. Though it lacks the rigour that the physicist will eventually require, the reader will find in the references at the end of each chapter an excellent guide to further study. There are also numerous problems of a practical nature at the end of each chapter, and the text is well illustrated by diagrams of exceptional clarity.

D. P. R. PETRIE.

REPORT OF A WORKING PARTY ON ANAESTHETIC EXPLOSIONS

London : Her Majesty's Stationery Office. Pp. 39. Price 2s. 6d.

Advances in medical science have done much to make the operating theatre a safer place than it was a few decades ago, but some important hazards still remain to worry the surgeon and his technical advisers.

An eminent bacteriologist recently asserted that 90 per cent of the sterilizers in British hospitals are ineffective, through neglect or ignorance of thermodynamical principles in their design and operation. Dangers associated with the use of combustible gases for anaesthesia are well understood by physicists but not always, it seems, by surgeons and anaethetists.

The Working Party appointed by the Minister of Health in 1953 has now produced its report—a model of clear thinking and concise explanation. Fires and explosions can be caused by sparks from switches and other electrical gear, or from surfaces bearing static charges. Three-quarters of these accidents could be eliminated by the general adoption of simple precautions already observed in a minority of hospitals ; conducting materials should be used for floors, footwear and clothing, and a high relative humidity should be maintained. Several lines of research are proposed, including the use of radioactive materials to ionize the air and the search for non-explosive anaesthetics.

The Working Party considers that the greatest problem is to make people in hospitals sufficiently aware of the dangers ; its report will certainly help in achieving this object.

J. M. A. LENIHAN.

Group News

1956 Summer Meeting on Non-Destructive Testing

The Summer Meeting of the Non-Destructive Testing Group was held at the University of Bristol from July 11 to 14. New aspects of non-destructive testing were discussed in a programme of lectures and papers concerned mainly with the development of new testing techniques. The main theme was the use of physical properties as a means of detecting structural and constitutional changes in materials.

Dr. S. G. Hooker, Director and Chief Engineer of Bristol Aero-Engines Limited, showed that the lack of adequate inspection techniques is a serious handicap to modern engineering development, and stressed the need for physicists to produce the right kind of fundamental information to serve as a basis for improved methods of testing. Dr. E. G. Stanford (*Aluminium Laboratories Ltd.*) emphasized the fact that, contrary to the conception held by many people, non-destructive testing is not confined to the detection of defects in engineering materials and components, but embraces the whole technology of industrial inspection and may also involve the whole of physics.

Professor W. Sucksmith (*University of Sheffield*) reviewed present knowledge of the influence which structural factors have on the magnetic properties of metals. Dr. D. E. Thomas (*Aluminium Laboratories Ltd.*) discussed the relationships between the electrical resistivity of metals and their mechanical properties, and Mr. S. F. Pugh (*Atomic Energy Research Establishment, Harwell*) described how the study of radiation damage is yielding information about the structure of solids.

In a session devoted to the problem of assessing the mechanical behaviour of metals, attention was confined to the phenomenon of fatigue. Dr. N. Thompson (*University of Bristol*) described some original work, carried out at the H. H. Wills Physical Laboratory, in which structural changes leading to the formation of a crack had been followed during the fatigue process, and Dr. R. F. Hanstock (*High Duty Alloys Ltd.*) discussed the use of damping capacity as a means

From left to right :

Mr. B. R. Byrne
Dr. E. G. Stanford
Mr. R. Halmshaw
Dr. R. F. Hanstock
Dr. J. Thewlis
Mr. W. E. Schall
Mr. E. R. Gadd
Professor W. Sucksmith
Mr. R. S. Sharpe
Mr. B. N. Burns

of detecting the onset of fatigue failure. Both Dr. Thompson and Dr. Hanstock produced conclusive evidence to show that there is no direct connexion between changes in damping capacity and progress towards fatigue failure.

Developments in new methods of non-destructive testing were described by Dr. L. E. Drain (*Atomic Energy Research Establishment, Harwell*) in his paper on "The Principles and Applications of Nuclear Magnetic Resonance," by Mr. W. A. Runciman (*Atomic Energy Research Establishment, Harwell*) in a paper entitled "Optical Fluorescence and Non-Destructive Testing," and by Mr. M. F. Markham (*National Physical Laboratory*) who presented a paper on "The Measurement of Elastic Constants by the Ultrasonic Pulse Method."

A review of the testing of non-metals was given by Dr. P. T. Barrett (*Imperial Chemical Industries Ltd. Terylene Council*), who showed how the physical properties of plastic fibres are used to examine their structure and how the mechanical properties of fibres are influenced by their structure. That the interests of the Non-Destructive Testing Group are not confined to the applications of physics in industry was underlined by Professor C. B. Allsopp (*Guy's Hospital, London*) who, in an Evening Discourse on "Physical Problems in Medical Diagnosis," drew attention to the important medical aspects of the work of the Non-Destructive Testing Group. Professor Allsopp aroused considerable interest by showing how physicists engaged on industrial problems can contribute to the solution of medical problems.

An account of the meeting would not be complete without a reference to the extremely interesting visit paid, at the invitation of the Bristol Aeroplane Company, to the production plants of that company. Nor should we omit to mention the very enjoyable trip by motor coach to the Cheddar Gorge and Caves. The papers and lectures presented at the Meeting will appear in a supplement to the *British Journal of Applied Physics* which will be published early in 1957.

E. G. STANFORD.

The Register

ELECTIONS TO MEMBERSHIP

THE FOLLOWING ELECTIONS WERE MADE BY THE BOARD ON DECEMBER 4, 1956

An asterisk (*) indicates transfer from another grade

FELLOWS

*Anstis, Albert Howard, B.Sc., Senior Scientific Officer, Ministry of Supply, Tolworth.

*Bennett, William Donald, B.Sc., Ph.D., Head of Reactor Development, General Atomic Division, Canadair Ltd., Montreal.

*Challice, Cyril Eugene, B.Sc., Ph.D., Junior Lecturer in Physics, St. Mary's Hospital Medical School, London.

*Dyer, Arthur James, M.Sc., Ph.D., Research Officer, C.S.I.R.O., Victoria, Australia.

*Leak, George Matthew, B.Sc., Ph.D., Deputy Head, Metallurgy Division, British Iron and Steel Research Association, London.

Powles, Jack Gordon, D.Sc., Ph.D., Reader in Experimental Physics, Queen Mary College, London.

*Stansfield, James Richard, M.A., Assistant to Controller of Research, Hilger & Watts Ltd., London.

*Whittaker, Eric James William, M.A., B.Sc., Ph.D., Manager, Chemical Research Department, Ferodo Ltd., Stockport.

ASSOCIATES

Ahern, Sean Alan, B.Sc., Ph.D., Senior Physicist, Mullard Research Laboratories, Surrey.

*Bell, John Robert, B.Sc., Research Fellow, University of Leeds.

*Buswell, Albert Geoffrey, B.Sc., Technical Officer, Imperial Chemical Industries Ltd. (Dyestuffs Division), Manchester.

*Canfor, Kenneth Ralph, B.Sc., Engineer, English Electric Co. Ltd., Kidsgrove.

*Chappel, Frank Patrick, M.Sc., Technical Officer, British Nylon Spinners Ltd., Pontypool.

Chester, Albert Eric, M.Sc., Ph.D., Principal Physicist, The Radium Institute, Royal Infirmary, Bradford.

Cooper, Paul Neville, B.Sc., Ph.D., Research Physicist, Associated Electrical Industries Ltd., Research Laboratory, Aldermaston.

Damodaran, Kochuparambil Kunjippennu, M.A., B.Sc., Ph.D., Research Fellow, University of Birmingham.

Denholm, James Robert, B.Sc., Depute Principal, Paisley Technical College, Renfrew.

*Dickson, Eric Winston, B.Sc., Ph.D., Research Physicist, Tube Investments Research Laboratories, Essex.

*Duckworth, George, M.A., B.Sc., Development Engineer, British Thomson Houston Co. Ltd., Rugby.

*Dyson, John Edmund, B.Sc., Assistant Lecturer, Huddersfield Technical College.

*Edwards, Ronald James, B.Sc., Junior Engineer, De Havilland Propellers Ltd., Herts.

*Ellis, Kenneth, B.Sc., Squadron Leader, Royal Air Force.

*Fisher, Peter, B.Sc., Ph.D., Research Associate, University of Purdue, U.S.A.

*Gameson, John Jeffreys, B.Sc., Technical Author, Ultra Electric Ltd., London.

*Godridge, Arthur Malcolm, M.Sc., Research Officer, British Coal Utilization Research Association, Leatherhead.

Goodspeed, Morley James, B.Sc., Geophysicist, Commonwealth Bureau of Mineral Resources, Australia.

Green, David Walter, M.A., Research Worker, Medical Research Council, London.

Heath, Frank, B.Sc., Senior Physics Master, Magnus Grammar School, Nottingham.

Hill, Stanley, M.A., Head of Physics Department, The Grammar School, Leeds.

Hodgson, John Noel, B.Sc., Ph.D., Assistant Lecturer, University College of North Staffordshire.

Jackson, Horace Leslie Wells, M.Sc., Lecturer, Nottingham and District Technical College.

Jackson, William Lewis, B.Sc., Senior Physicist, Dunlop Cotton Mills Ltd., Lancashire.

Jeffries, Thomas Oliver, M.A., D.Phil., Physicist, Atomic Power Branch, The English Electric Co. Ltd., Leicester.

Jenkins, Ieuan Miles Lewis, B.Sc., Physics Master, Newport Grammar School, Essex.

*Johnston, John McKillop, Physicist, Babcock & Wilcox Ltd., Renfrew.

*Kalman, Peter, B.Sc., The Anchor Glass Co. Ltd., London.

*Lamden, Ralph James, M.Sc., Physicist, Ferranti (Edinburgh) Ltd., Edinburgh.

*Legge, Ivo Keith Bysshe, B.Sc., H.M. Inspector of Factories, Ministry of Labour and National Service, Yorkshire.

Lewis, David, M.Sc., Lecturer, Battersea Polytechnic, London.

Lewis, John Rodney Haig, Experimental Officer, Admiralty Engineering Laboratory, Middlesex.

Lovell, Frederick Maurice, B.Sc., Scientific Officer, Ministry of Supply, Kent.

McCloskey, Hugh Anthony, B.Sc., Research Engineer, Ferranti Ltd., Edinburgh.

Micco, Leopoldo A., B.A., M.Sc., Senior Research Physicist, Ansco, New York.

*Miller, Alexander John, B.Sc., Pottery Development Manager, Twyfords Ltd., Stoke-on-Trent.

*Moon, Bruce Alex McGeorge, M.Sc., Higher Scientific Officer, W.R.E. Department of Supply, Australia.

North, Anthony Charles Thomas, B.Sc., Ph.D., Research Fellow, Royal Institution, London.

*Oliver, Philip Herbert, B.Sc., Research Physicist, Courtaulds Ltd., Manchester.

Pengelly, Alan Ernest Shelly, B.Sc., Senior Physicist, International Flame Radiation Foundation, Holland.

*Possener, Michael N. A., M.Sc., Scientific Staff, The General Electric Co. Ltd., Wembley.

Power, Geoffrey M.A., Ph.D., Lecturer, University of Nottingham.

*Pratt, Ronald George, B.Sc., Physicist, Mullard Research Laboratories, Surrey.

Puttock, Maurice James, B.Sc., Senior Research Officer, National Standards Laboratory, C.S.I.R.O., Australia.

Salgado, Chandrasena Aladin Kenneth, B.Sc., Group Leader, Dunlop Rubber Co. Ltd., Birmingham.

*Scott, Hazel Mortimer, B.Sc., Experimental Officer, Mechanical Engineering Research Laboratory, D.S.I.R., Glasgow.

Shannon, Robert Edward, B.Sc., Physicist, The General Electric Co. Ltd., Stanmore.

*Slater, Ronald Henry, B.Sc., Assistant Engineer, The English Electric Valve Co., Ltd., Chelmsford, Essex.

Smith, Reginald William, B.Sc., Ph.D., Tin Research Investigator, University of Birmingham.

Spurr, Geoffrey, B.Sc., Assistant Engineer, Central Electricity Authority, Leatherhead.

Swinbank, Peter, B.Sc., Ph.D., Research Fellow, University of Glasgow.

*Thomas, Hywel Watcyn, B.Sc., Ph.D., National Service.

*Tarnowski, Andrew, B.Sc., Research Physicist, Eastman Kodak Co., New York.

Tirmizi, Syed Masoom Ali, M.Sc., Lecturer, University of Karachi, Pakistan.

*Williams, Godfrey James, B.Sc., Physicist, Solartron Electronic Group Ltd., Surrey.

Wilson, Geoffrey Wilfred, B.Sc., Metallurgist, High Duty Alloys Ltd., Bucks.

GRADUATES

Atkins, Francis James, B.Sc., Research Assistant, The Electrical Research Association, Perivale, Middlesex.

Auton, Joan Winifred, B.Sc., Assistant Experimental Officer, Admiralty Signal and Radar Establishment, Hants.

Barton, Colin John, B.Sc., Student, Education Department, University of Reading.

Beckett, Ann Patricia, B.Sc., Investigator, Aluminium Laboratories Ltd., Banbury, Oxon.

Branton, John Francis, B.Sc., Technical Signals Officer, Royal Air Force, Herts.

*Brook, Keith Reginald, B.Sc., Technical Engineer, Guided Weapons Instrumentation Laboratory, Bristol Aircraft Ltd., Bristol.

Brown, Ian David, B.Sc., Research Student, Davy-Faraday Laboratory, Royal Institution, London.

Burrows, Keith, B.Sc., Physicist, Hunting Geophysics Ltd., Herts.

Clarke, John Owen, B.Sc., Research Assistant, University of Durham.

Cornish, Eluned, B.Sc., Technical Officer, British Nylon Spinners Ltd., Pontypool.

Crisp, Frank Norman, B.Sc., Assistant Master in Physics, Chiswick County Grammar School for Boys, Middlesex.

*Derrick, Graham Holbrook, B.Sc., Research Student, University of Sydney, Australia.

Dobson, John Graham, B.Sc., Electro-Mechanical Engineer, Sperry Gyroscope Co. Ltd., Middlesex.

Duncumb, Peter, B.A., Research Student, Cavendish Laboratory, Cambridge.

Finch, John Thomas, B.Sc., Research Student, Birkbeck College, London.

Forrester, John David, B.A., Research Student, University College, London.

Goodman, Michael John, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Hants.

*Grodszinsky, Ernest Juergen, B.Sc., Group Leader, Electronic Tubes Ltd., Bucks.

Gunston, Mark Antony Richard, B.Sc., Junior Engineer, English Electric Valve Co. Ltd., Chelmsford, Essex.

Hajjarizadeh, Hossein Ali, B.Sc., Lecturer, Abadan Technical Institute, Abadan.

Harris, Keith Dillon, B.Sc., Assistant Engineer, English Electric Valve Co. Ltd., Chelmsford, Essex.

Harvey, Keith Bryan, B.Sc., Assistant Technical Officer, Steatite and Porcelain Products Ltd., Worcestershire.

Hatcher, Anthony Roland, B.Sc., Graduate Trainee, Deptford East Power Station.

Hayward, Cyril John, B.Sc., Student, Education Department, Queen's College, Dundee.

House, David George, B.Sc., Research Student, University of Southampton.

Hudson, Robert Douglas, B.Sc., Research Student, University of Reading.

Hughes, Anne Florence, B.Sc., Technical Officer, British Nylon Spinners Ltd., Pontypool.

Hurle, Donald Thomas James, B.Sc., Postgraduate Research Student, University of Southampton.

Hurt, Francis Neil, B.Sc., Research Physicist, British Plaster Board (Holdings) Ltd., Leicester.

Johnson, Philip Ian, B.Sc., Technical Assistant, Mitcham Works Ltd. (Philips Radio), Croydon.

Kenny, Peter, B.Sc., Scientist, National Coal Board, Isleworth, Middlesex.

*Kumar, Satyendranath, M.Sc., Development Engineer, A. C. Cossor Ltd.

Laine, Derek Charles, B.Sc., Research Assistant, University of Southampton.

*Lesford, Derek James, B.Sc., Postgraduate Research Student, University College of London.

Lynch, Nigel Alfred, B.Sc., Technical Assistant, M.O. Valve Co. Ltd., Brook Green, Hammersmith, W.6.

Marshall, David, B.Sc., Technical Assistant, Nuclear Engineering Department, H. M. Hobson Ltd., Wolverhampton.

Morrison, Jeffrey, B.Sc., Electronics Engineer, English Electric Co. Ltd., Lancashire.

Port, John Joseph, B.Sc., Student, University of Southampton.

Price, Desmond Alfred, B.Sc., Research Student, University College, Cardiff.

Prutton, Martin, B.Sc., Research Student, Birkbeck College, London.

Purdie, Joseph Albert, B.Sc., Electronic Development Engineer, Rotax Ltd., London.

Rutherford, Gilbert Selby Walker, B.Sc., Lecturer, Dundee Institute of Art and Technology, Dundee.

Sherlock, James Francis, B.Sc., Student Apprentice, Automatic Telephone and Electric Co. Ltd., Liverpool.

Simmons, Jack Alexander, B.Sc., Student, St. Bartholomew's Hospital, London.

Sinclair, Thomas Malcolm, B.Sc., Probationer Assistant, The British Petroleum Co. Ltd., London.

Smith, Derek, B.Sc., Junior Engineer, Electric and Musical Industries Ltd., Middlesex.

Tavendale, Alister James, M.Sc., Experimental Officer, The General Electric Co. (England) Ltd., South Australia.

Taylor, Peter Laurence, B.A., Research Physicist, Atomic Reactor Control Department, H. M. Hobson Ltd., Wolverhampton.

Tilsley, David Newman, B.Sc., Assistant, Borough Polytechnic, London.

Towlson, Peter Guy, B.Sc., Lecturer, Faraday Electrical Engineering College, London.

White, Michael Francis, B.Sc., Junior Engineer, Electric and Musical Industries Ltd., Middlesex.

57 Students and 5 Subscribers were also admitted.

The Institute's Journals

PRINCIPAL CONTENTS OF THE JANUARY, 1957, ISSUES

Journal of Scientific Instruments: Volume 34, No. 1

SPECIAL ARTICLE

Post-war developments in geophysical instrumentation for oil prospecting. By D. T. Germain-Jones, F.Inst.P. (*British Petroleum Co. Ltd., London*).

Noteworthy advances have been made in geophysical apparatus for oil prospecting purposes over the past twelve years. Highly sensitive apparatus for accurate registration in an aeroplane of anomalies in the earth's magnetic field is being employed with considerable success. Gravimeters weighing only 5 lb and measuring changes in the earth's gravitational field with an accuracy of the order of 1×10^{-8} *g* are in widespread use. Highly portable low frequency seismic apparatus will register with ease refracted waves up to distances of twenty miles, and seismic reflexion equipment of complex design, but rugged and portable, will record reflexions of various frequencies from depths of many thousands of feet. Routine seismic surveys are conducted from ships over water-covered areas, and for accurate location purposes on surveys over prospects under the sea it is customary to employ radio surveying aids. The recent introduction of magnetic recording for seismic surveys offers wide scope for improvements in the seismic technique; and new methods of displaying the recorded information are likely to help greatly the process of interpretation. Remarkable ingenuity has been shown in the development of radioactive and other forms of well-logging devices.

ORIGINAL CONTRIBUTIONS

Contrast arising from elastic and inelastic scattering in the electron microscope. By M. E. Haine, F.Inst.P. (*Associated Electrical Industries Ltd., Aldermaston, Berks*).

The contrast due to elastic and inelastic scattering of electrons in the electron microscope is calculated on a wave-optical basis. Various approximations are made, especially in the case of inelastic scattering where additional scattering data is required for a rigorous analysis. It is shown that the major contribution to contrast arises from the gap left in the illuminating wavefront by the inelastically scattered electrons. The next most important effect is by phase contrast with elastic scattering. In-phase or amplitude contrast is very small, and the inelastically scattered electrons have little effect except for extended objects.

Two optical instruments used in semiconductor research. By D. G. Avery, A.Inst.P. (*Radar Research Establishment, Great Malvern, Worcs*).

A single-prism monochromator and a light-spot microscope are described. The monochromator, aperture *f*/3, is intended for low resolution work, and employs a Littrow-mounted prism and a single lens. Typical figures for scattered light intensities at various wavelengths are given. The light-spot microscope, which uses a reflecting objective, provides a spot of light which can be as small as 10μ in diameter. The spot can be positioned accurately on the semiconductor surface with the aid of two micrometer adjustments; the whole area around the spot is visible through the microscope whilst the instrument is in use.

Operation of a diffusion cloud chamber with 23 atm of deuterium. By A. P. Batson, B. B. Culwick, H. B. Klepp and L. Riddiford (*Department of Physics, University of Birmingham*).

The successful operation of an 18 in. diameter diffusion cloud chamber filled with deuterium at a pressure of 23 atm is reported. The importance of the tritium and oxygen content are discussed. An account of the apparatus for the manufacture and transfer of the deuterium is given.

A constant-current device for use in the measurement of transference numbers by the moving-boundary method. By D. T. Hopkins, and A. K. Covington (*Chemistry Department, University of Reading*).

A circuit is described which will supply a current of between 0·5 and 2·5 mA, constant to 0·1%, with a ten-fold load impedance change, in the range 5–500 kΩ.

A bent crystal X-ray spectrograph. By G. B. Deodhar, F.Inst.P., and R. C. Karnatak (*Physics Department, University of Allahabad, India*).

Details of the principle and construction of a new design of bent crystal spectrograph of the transmission type are described. Different possible settings of the instrument with respect to the X-ray beam are discussed and advantages over the previous designs pointed out.

A linear, temperature compensated hot-wire anemometer. By E. L. Deacon, A.Inst.P., and D. R. Samuel (*Division of Meteorological Physics, Commonwealth Scientific and Industrial Research Organization, Aspendale, Victoria, Australia*).

A hot-wire anemometer is described which gives a linear output over the range of wind speed 1 to 16 m/s and is therefore well suited to studies of atmospheric turbulence. It is also provided with temperature compensation so that the effects of air temperature fluctuations (both rapid and slow) are eliminated. These desiderata are achieved with little increase in complexity over the simple hot-wire circuit.

Measurement of high viscosities by shearing between parallel plates. By F. E. Humphreys and N. Stone (*The British Leather Manufacturers' Research Association, Egham, Surrey*).

Viscosities in the range 10^4–10^7 poises have been measured by shearing thin films between two parallel stainless steel plates. In this way frictional heat is rapidly dissipated, temperature being registered by a thermistor.

A portable ionization current comparator. By L. A. W. Kemp, F.Inst.P., and B. J. Banfield (*The London Hospital Research Laboratories, Ashfield Street, London, E.1*).

A self-contained and portable version of the Kemp ionization current comparator is described in practical detail. The instrument employs a single sub-miniature electrometer valve (run from Mallory dry cells) in a null circuit, together with a taut-suspension reflecting galvanometer system, which is built-in. From the direct-reading linear scale, the ratio of one ionization current to the other may be read off as a percentage of the initial value obtaining for this ratio in a series of experimental readings. The instrument has many applications in radiological work, in which a separate radiation monitor would otherwise be necessary in order to eliminate the effects of X-ray intensity fluctuations. Observations with an accuracy better than 1 per cent can be made with ease.

British Journal of Applied Physics: Volume 8, No. 1

ORIGINAL CONTRIBUTIONS

The nature of the emitting surface of barium dispenser cathodes. By I. Brodie, A.Inst.P., and R. O. Jenkins, F.Inst.P. (*Research Laboratory, The General Electric Co. Ltd., Wembley, Middlesex*).

Data concerning the thermionic emission and evaporation characteristics of various barium dispenser cathodes are examined. It is deduced that the tungsten surface of an "L"-type cathode must be covered with a layer of oxygen on which the barium is adsorbed. The thermionic emission from cathodes impregnated with barium aluminate results from a similar layer on the tungsten, the emission from the impregnant at the ends of the pores contributing relatively little. When the impregnant is barium-calcium-aluminate, however, the considerable increase in emission is mainly due to enhancement of the emission from the impregnant and not to an increase in that from the activated tungsten. It is postulated that the emitting surface of the impregnant may be a thin layer of calcium oxide activated by barium.

CONFERENCE REPORT

Summarized proceedings of a conference on the electron microscopy of fibres—Leeds, January, 1956.

A conference on the electron microscopy of textile and other industrial fibres was held on January 3 and 4, 1956, in the Department of Textile Industries, University of Leeds. The conference was organized by the Textile Physics Laboratory, under the auspices of The Institute of Physics. Seventeen of the eighteen papers are summarized. Many of the papers evoked stimulating informal discussion.

The determination of linear distortion in nuclear emulsions. By A. J. Apostolakis and J. V. Major (*Department of Physics, Durham Colleges in the University of Durham*).

The ratio of the linear distortion vector to the curvature distortion vector is found to be $(2{\cdot}03 \pm 0{\cdot}03)$ within the temperature range (for hot-stage development), of 15–24°C. The vectors are found to be in opposite directions. Some consequences of distortion are considered.

The X-ray and γ-ray absorption coefficients o a number of glasses. By D. A. Richardson, A.Inst.P. (*Pilkington Bros. Ltd., St. Helens, Lancashire*).

From published data, the X-ray absorption coefficients of a number of glasses have been computed over a wavelength range of 0·01–1·0Å. The glasses are clear white plate, ceria stabilized plate, 1060 CRT glass, light barium crown 541595, lead plate glass and double extra dense flint glass 927210.

The mass absorption coefficients for most oxides used in glassmaking are plotted as a function of wavelength, and a method of calculating the absorption coefficient of any glass from its composition and this graph is presented.
Lead equivalents for the γ-ray region of some glasses are given as a function of glass density. The glasses considered are ceria stabilized plate ; the barium series 541595, 572577, 612585 and 623603 ; and the lead series 653335, 700303, 748278, 801255, 927210 and lead plate glass. (The numbers given are the type reference numbers given in the catalogue of Chance optical glass.)

A tilting stage method for three-dimensional photoelastic investigations. By H. T. Jessop, F.Inst.P. (*University College, London, W.C.1*).

A method of finding the directions of the principal axes of stress at any point of a " frozen " photoelastic model by the use of a simplified form of universal tilting stage is described. This results in more direct and more accurate measurement of the principal stress-differences at the point.

The triple point of carbon dioxide as a thermometric fixed point. By D. Ambrose, (*Chemical Research Laboratory, Teddington, Middlesex*).

In the technique described, a cell provided with a thermometer pocket was filled with purified carbon dioxide and cooled in a stirred-liquid bath to − 56·6°C. The three-phase equilibrium was then established and the temperature of a thermometer inserted in the cell remained constant, provided that the temperature of the bath was maintained at − 56·6 ± 0·5°C. The value found for the triple-point temperature was − 56·603°C. with a reproducibility of ± 0·002°C.

The measurement of the thickness of thin carbon films. By A. W. Agar, A.Inst.P. (*Associated Electrical Industries Ltd., Aldermaston, Berks*).

A nearly linear relationship has been found to exist between the optical density and the thickness of evaporated carbon films. The determination of film thickness by density measurements is shown to have a number of advantages over measurement by interferometry, particularly for very thin films.

The flow of gas through composite systems at very low pressures. By C. W. Oatley (*Engineering Laboratory, Cambridge*).

It is shown that the conventional method of calculating the flow of gas at very low pressure through composite systems is based on an untenable assumption and leads to incorrect results. An improved method of calculation is given which, though not exact, is unlikely to lead to errors exceeding a few per cent. The physical basis of this method is discussed and its application to various problems of practical importance is considered.

An electrical analogue of magnetic domains. By P. F. Davis (*University of Nottingham*).

An electrical analogue which may be used for finding either the magnetic energy or the field associated with a domain structure consists of a square mesh network of resistance wires composed of different gauges of wire running in different directions ; the wires having the highest resistance per unit length run in the direction analogous to the direction of magnetization of the domain. (A three-dimensional form might consist of parallel plates of resistive material immersed in an electrolytic tank.)

The breakdown mechanism of certain triggered spark gaps. By T. E. Broadbent (*Electrical Engineering Department, University of Manchester*).

Experiments designed to investigate the breakdown mechanism of certain triggered spark gaps in air are described. Possible theories of the breakdown mechanism of the trigatron and the thermally triggered spark gap are put forward, based on experimental voltage and time lag to breakdown characteristics, corona measurements, and on optical studies using a photomultiplier. It is shown that the mechanism of breakdown for the two forms of triggered spark gap may be similar and depend, with positive charging polarities, on the movement of positive ions followed by a streamer process, and, in the case of negative charging polarities, on a streamer process only.

Barium getters and oxygen. By R. N. Bloomer, A.Inst.P. (*Associated Electrical Industries Ltd., Aldermaston, Berks*).

The sorption of oxygen by films of barium evaporated in a vacuum has been studied. The speed of pumping and the capacity were measured. The speed of pumping has been found to be almost independent of the ionizing electron current in the oxygen gas. However, towards the end of the life of a film, it was found that all pumping ceased unless a hot tungsten filament was alight in the gas. Measurements of the variation of speed in the early life of a getter film, and of the influence of evaporation conditions upon pumping, show the importance of nucleation centres at which oxidation starts. The increase of speed and capacity with temperature show that these are limited by diffusion processes within the getter film.

British Thomson-Houston Co. Ltd. have vacancies in their Research Laboratories at Rugby for graduate physicists (male or female) to carry out investigations, both fundamental and short term, in a number of different research projects. Previous research experience is not essential for some of the posts, but it is envisaged that applicants with such experience or higher degrees would subsequently lead small research teams.

These posts offer excellent opportunities for carrying out original research unhampered by equipment difficulties. Every facility is given for the publication of results and for participating in other scientific activities.

Applicants are invited to write to the Director of Research, British Thomson-Houston Co. Ltd., Rugby, giving particulars of age, qualifications and experience, quoting reference WB.

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The Company is a large well-known and well-established concern in this field and the work of the Research Laboratories is concerned with the problems arising in the production and development of a wide range of high-grade alloy steels. A salary commensurate with age, qualifications and experience will be paid.

Applications should be made in the first instance in writing, stating age, full details of academic qualifications and experience to: Ref. LB/MV/Emp. Thos. Firth and John Brown Ltd., Atlas Works, Sheffield 4.

BRITISH THOMSON-HOUSTON CO. LTD. has vacancies in its Research Laboratory at Rugby for graduates for research in problems of gas discharges. Applicants are invited to send details of their age, qualifications and experience to the Director of Research, The British Thomson-Houston Co. Ltd., Rugby, quoting reference KB.

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Salary: £375 (age 18)—£665 (age 26 or over)—£815 p.a. (male). Contributory superannuation scheme. A house, or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

Postcards for application forms to Senior Recruitment Officer at above address, quoting ref. 1366/110.

CAMBRIDGE INSTRUMENT CO. LTD., has a vacancy in its Research Department at Cambridge for a physicist with a degree or similar qualification and a few years' experience of the application of electronic methods to the measurement of physical quantities. Initially the work will have a bias towards electro-medical methods.

The post involves the direction of younger graduates and technical staff dealing with electronic problems. It is permanent and pensionable.

Applications giving details of education, experience and present post should be addressed to the Head of the Research Department.

NUCLEAR PROJECTS GROUP

A small but expanding design team has been established in the West End of London. Applications are invited from qualified men aged 24–28 years to fill the following positions :

(1) **Mathematical Physicist to carry out nuclear calculations on reactor core and shield.**

(2) **Applied Mathematician to investigate control problems. Knowledge of servo-mechanism theory desirable.**

Proposed salaries are up to £1,000 per year dependent upon qualifications, age and experience, and successful applicants will be afforded the opportunity of attending the Reactor School at Harwell.

Particulars of qualifications, age, experience, etc., should be forwarded to :

The Personnel Officer
The de Havilland Engine Company Ltd.
Stag Lane, Edgware, Middlesex

EXPERIMENTAL OFFICERS
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REQUIRED BY
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to work on development of high speed transient recording oscillographs and pulse type amplifiers. E.O. applicants should be aged 26 and have H.S.C.(Science) or equivalent : a pass degree in physics or electrical engineering (emphasis on electronics) desirable. Experience in design of short duration pulse circuits or high speed oscillography preferred.

Salary : Experimental Officer—£940 – £1,155 p.a. (male) ;
Assistant Experimental Officer—£375 (age 18) – £665 (at age 26 or over) – £815 (male).

Contributory superannuation scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

Postcards for application forms to Senior Recruitment Officer at the above address. Please quote Ref. 1352/110.

FINE POWDERS. Young scientist wanted for investigation of production and properties of fine powders, with interest in operational research. Publication encouraged of suitable original work. Central Research Laboratories in Herts, five-day week. excellent superannuation arrangements. Initial salaries up to £1,000. Full details in confidence to the Director of Research, Research Council of the British Whiting Federation, The Hall, Welwyn, Herts.

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(Provisionally designated as a College of Advanced Technology)

Principal : A. HARVEY, Ph.D., B.Sc., F.Inst.P.

Applications are invited for the following new posts :—

(i) Head of the Department of Electrical Engineering : This department is now being established as a separate entity and applicants should be capable of developing the work to the highest level. The post will be a Grade IV headship.

(ii) Senior Lecturer in Applied Physics : Applicants must have good industrial or similar experience in Applied Physics and be capable of developing courses in this field.

The salaries are as follows : Grade IV Head £1,750 × 50 – £1,900 ; Senior Lecturer £1,350 × 50 – £1,550.

Further particulars and forms of application may be obtained from the undersigned on receipt of a stamped addressed envelope. Completed forms should be returned as soon as possible.

Robert E. Presswood,
Director of Education.

City Hall, Cardiff.

BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION

Nucleonic Instrumentation

Electronic engineers and physicists with a good knowledge of electronics who wish to enter the field of nucleonic instrumentation are invited to apply for an important post in this rapidly expanding subject.

The successful candidate will be given the opportunity of working at A.E.R.E. for a period. He is expected eventually to become the head of the department of nucleonics at B.S.I.R.A. The salary range is £800 to £1,300 per annum, with F.S.S.U. benefits, and promotion to higher grades is dependent solely upon merit.

Applications, including two references, should be addressed to the Director, J. Thomson, M.A., D.Sc., F.Inst.P., M.I.E.E., at the Association's laboratories, Sira, South Hill, Chislehurst, Kent, and should be received not later than March 31, 1957.

NATIONAL COAL BOARD

MECHANICAL ENGINEERS AND PHYSICISTS. Coal remains the nation's basic source of power for the foreseeable future. The National Coal Board's Mining Research Establishment at Isleworth, Middlesex, is concerned with evolution of principles of design for new coal mining machinery, also with investigating the physical and mechanical properties of coal and rock, basic processes of coal and rock working, problems of roof support and strata control, underground transport, instrumentation and the maintenance of an environment safe in regard to dust, gas, etc. The work is of considerable national importance, interesting and rewarding, involving field work as well as laboratory research investigation. The Establishment is situated in congenial surroundings in the London area. Vacancies, superannuable, exist in the following grades : *Scientist 1* or *Senior Scientist*—Mechanical Engineer (inclusive scale/range from £1,365 to £2,100 male) or *Scientist 2/3*—Mechanical Engineers and Physicists (inclusive scales from £617 to £1,390 male), according to qualifications and experience. Good honours degree, and relevant experience for the higher grades are required. *Scientific Technical Officers 2 and 3* with qualifications in mechanical engineering and physics are also required (inclusive scales from £472 to £839 male).

Write for application form to National Coal Board, Mining Research Establishment, Worton Hall, Isleworth, Middlesex.

THE G.E.C. is establishing a Development Laboratory at its Lamp Division near Manchester, which manuactures tungsten filament lamps, discharge lamps and electrical discharge devices. The laboratory will study new methods of manufacture, and the potentialities of new light sources. This group will work in close collaboration with the Company's central research laboratories at Wembley. Applications are invited from those interested in experimental work in the high vacuum and light engineering fields. Vacancies exist for male and female applicants in the following categories :—

(1) Physics graduates (honours level in physics).

(2) Holders of H.N.C. in mechanical or electrical engineering.

(3) Technical Assistants with O.N.C. in mechanical or electrical engineering.

(4) Student Assistants with G.C.E. in four subjects.

(5) Technical Operators (female).

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Apply in writing giving full details of age, education and experience to the Personnel Officer, Osram Lamp Works, Cape Mill, Refuge Street, Shaw.

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(2) **A PHYSICIST** to work, in the first place, on the generation, propagation and application of ultrasonic radiation. Candidates should have a good Honours Degree in Physics.

These positions, which involve responsible work, offer good prospects to the right man. The conditions of employment are excellent and include membership of the Pension Fund, a Profit-Sharing Scheme, and good sports and recreational facilities. Help can be given to married men in connexion with house purchase and removal expenses.

Applications should be made in writing, giving particulars of age, qualifications and experience, to Staff Manager, Imperial Chemical Industries Limited, General Chemicals Division, Cunard Building, Liverpool, 3.

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Applications are invited for I.C.I. Research Fellowships in Biochemistry, Chemistry, Engineering, Pharmacology, or Physics, to which some appointments may be made during the current academic year. The appointments will date from October 1, 1957. The Fellows will hold the status of Lecturers in the University. The salary will depend upon qualifications and experience, but will be within the range £600–£900 per annum, together with F.S.S.U. benefits and family allowances. Applications (eight copies) with a list of publications and names of two referees, should be sent not later than February 28, 1957, to the undersigned, from whom further particulars may be obtained.

Robt. T. Hutcheson,
Secretary of University Court.

BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION

Applications are invited for the following appointments at the E.D.A. Testing House, Leatherhead :—

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(2) Assistant Test Engineer. Minimum qualification O.N.C. or equivalent in engineering or applied physics. The salary will be on a scale £520 to £595 per annum.

Write full details to Director and Secretary, British Electrical Development Association, 2 Savoy Hill, London, W.C.2.

The Institute of Physics

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Errors of observation and their treatment

J. TOPPING, PH.D., F.INST.P., *Principal, Acton Technical College*

Every teacher of experimental physics knows how "results" given to three or four decimal places are often in error in the first place ; students suffer from "delusions of accuracy." At a higher level too, more experienced workers sometimes claim a degree of accuracy which cannot be justified. A consideration of the topics discussed in this monograph may stimulate in students an attitude to experimental results at once more modest and more profound.

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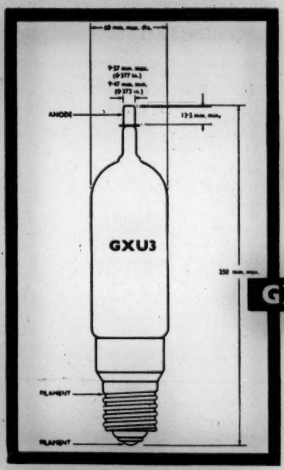

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